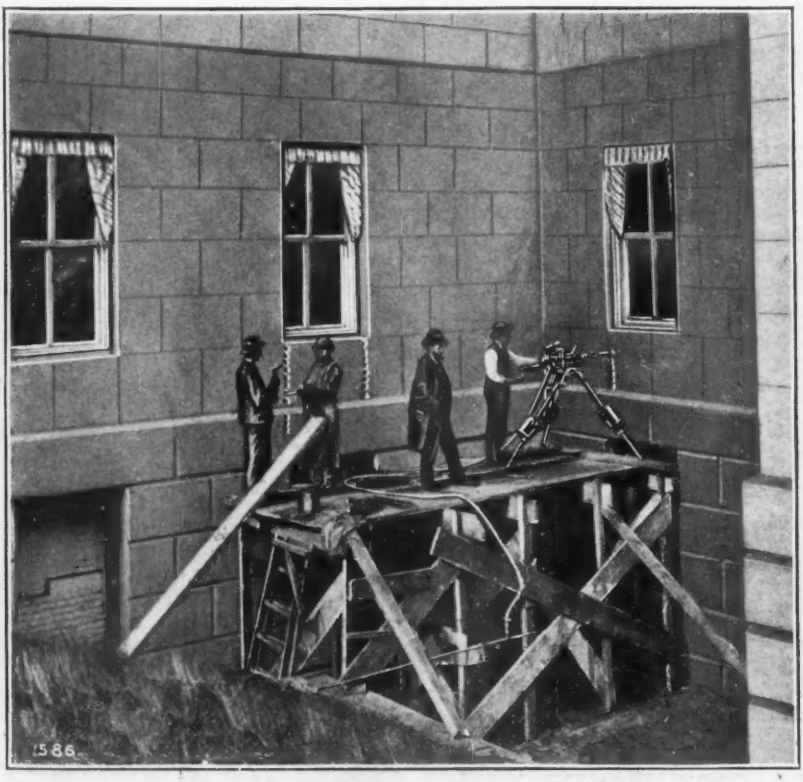
Index repeated in May

GENERAL LIBRARY,
UNIV. OF MICH.
FEB 28 1902

Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. VI. NEW YORK, FEBRUARY, 1902 No. 12.



A NOVEL AND USEFUL APPLICATION OF THE POWER DRILL.

LIDGERWOOD M'F'G CO.,

Boston.
Philadelphia.
Cleveland, O.

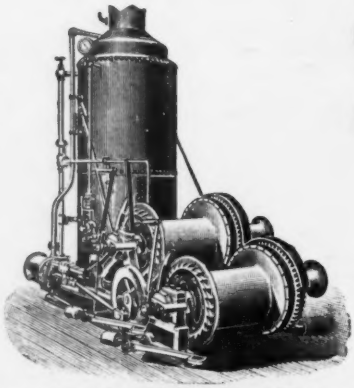
96 Liberty Street,
New York.

Chicago.
Portland, Ore.
New Orleans.

STANDARD

High-Speed Hoisting Engines.

Built on the Duplicate Part System.



Cableways, Hoisting AND Conveying Devices,

For Canal and Trench Excavating, Dam Construction, Wall and Pier Building, Mining, Quarrying, Logging, and General Contract Work.

Fiske Brothers Refining Co.

NON-CARBONIZING OIL

FOR USE IN AIR CYLINDERS OF

AIR COMPRESSORS,

Also All Grades of Lubricants for use on Machinery Propelled by Compressed Air.

Office and Salesroom, No. 59 WATER ST., NEW YORK, U. S. A.

CABLE ADDRESS "LUBROLEINE."

LONDON OFFICE: 9 NEW BROAD STREET, LONDON, E. C.

SOLE AGENTS FOR SCOTLAND: JOHN MACDONALD & SON, GLASGOW, SCOTLAND.

FOR

THE WORK OF THE DRILL.

FOR ALL PURPOSES:

COAL, IRON, STONE, WATER, GOLD, SILVER, OIL, COPPER, TIN, ETC.

....SEE....

"Boring and Drilling"

AN ILLUSTRATED TECHNICAL MONTHLY.

Methods of Boring. New Appliances. Sections of Strata, Etc.

RECORDED.

Editorial Office:
33 STRAND,
LONDON, W. C.

Subscription:
For the year, - - - 10s. with postage.
Single copies, - - 1s.

SEE SEPTEMBER NUMBER FOR SPECIAL ILLUSTRATED REPORT OF BORING ENGINEERS' CONGRESS AT FRANKFORT. - PRICE 2s.

JUST ISSUED.

Pumping by Compressed Air

By EDWARD A. RIX,
M. Am. Soc. M. E.
M. Am. Soc. C. E.

Price 75 Cents.

A practical treatise on this subject, containing valuable information, with diagrams and tables The different systems are described and compared, and the advantages of each impartially stated.
Forwarded postpaid on receipt of price.

COMPRESSED AIR,
26 Cortlandt Street, - - New York City.

An Important Connecting Link in Compressed Air Service.

THE

Moran Flexible Joint

For high pressure, indispensable.

Tightness, safety, flexibility and durability assured.

Parties making experiments with Compressed Air may have the use of the "Moran Joint" free for a limited time.

MORAN FLEXIBLE STEAM JOINT CO.,

LOUISVILLE, - - - - - - KENTUCKY.

THE PULSOMETER STEAM PUMP

"The Contractor's Friend."

OFTEN IMITATED—NEVER EQUALED.
OVER 20,000 IN USE.

Recent Important Improvements.

The Handiest, Simplest and Most Efficient Steam Pump for General Low Service Mining, Quarrying, Railroad, Irrigating, Drainage, Coal-washing, Tank-filling, Paper Mill, Sewer and Bridge Contractors' Purposes, etc., etc.

Muddy or gritty liquids handled without injury to the Pump.

PULSOMETER STEAM PUMP CO.

Catalogue on Application. **Correspondence Solicited**

135 GREENWICH STREET, NEW YORK.

The B. F. Goodrich Company.

AKRON RUBBER WORKS. FACTORIES: AKRON, OHIO, U. S. A.

NEW YORK: 66-68 Reade Street. CHICAGO: 141 Lake Street. SAN FRANCISCO: 35 New Montgomery Street.

Rubber Goods

OF FINE QUALITY.

HOSE FOR ALL PURPOSES.

AIR HOSE for Rock Drills, Compressors, Mining Machines, Pneumatic Riveters, etc.

ILLUSTRATED CATALOGUE.

STEAM HOSE, Etc.

Belting, Springs of all kinds, Valves, Gaskets, Rings, Packing, etc., etc.

No Floats or Submerged Working Parts.

Section of Chambers.

In sizes from 10 gallons per minute up.

Duplex Displacement Type.

WRITE FOR CIRCULAR.

THE MERRILL PNEUMATIC PUMP Operated by COMPRESSED AIR.

Suited to All Conditions and Places from Which Water is Taken.
Sent on Trial to All Parts of the Country.
Single and Duplex Displacement and Piston Types
Can be Installed by Any Mechanic.

MERRILL PNEUMATIC PUMP CO.,

141 Broadway, New York.

"Compressed Air"

Published Monthly.

This is the only publication devoted to the useful application of compressed air, and it is the recognized authority on all matters pertaining to this subject.

NOW IN ITS SIXTH YEAR.

RATES OF SUBSCRIPTION.

United States, Canada and Mexico,	per year,	$1.00
All other Countries,	"	1.50
Single Copies,		.10

SPECIAL.

Clubs of ten subscribers, ... 5.00

The attention of Engineers, Superintendents, Railroad Master Mechanics, Manufacturers of Compressed Air Appliances, Students, and all others whose association with compressed air require the widest knowledge of the application of air power is called to this ***Special Rate***. It enables them to place the magazine in the hands of operators of compressed air apparatus by club subscriptions at an extremely low cost.

LIST OF BOOKS ON COMPRESSED AIR.

Volume No. 5, Compressed Air," . . . . . cloth, 2.00

March, 1900—February, 1901, inclusive. The twelve numbers of "Compressed Air," which make up this volume are profusely illustrated with fine half-tone engravings and line cuts of a large number of important applications of compressed air.

"Compressed Air Production," by W. L. Saunders, ... cloth, 1.00

Compressed Air Production or The Theory and Practice of Air Compression. By W. L. Saunders. A practical treatise on air compression and compressed air machinery. It contains rules, tables and data of value to engineers

"Pumping by Compressed Air," by Edward A. Rix, ...75

A practical treatise on this subject, containing valuable information, with diagrams and tables. The different systems are described and compared, and the advantages of each impartially stated.

"Compressed Air," by Frank Richards, ... cloth, 1.50

Compressed Air, by Frank Richards. Contains practical information upon air compression and the transmission and application of compressed air.

"Liquid Air and the Liquefaction of Gases," by Prof. T. O'Conor Sloane, 350 pages, 2.50

Experiments upon the Transmission of Power by Compressed Air in Paris, by A. B. W. Kennedy, F. R. S., M. Inst. C. E., Emeritus Professor of Engineering in University College, London. The Transmission and Distribution of Power from Central Station by Compressed Air, by William Cawthorne Unwin, B. S. C., F. R. S., M. Inst. C.E., ...50

The Transmission of Power by Compressed Air, by Robert Zahner, M. E., . .50

"Tunneling," a practical treatise, by Charles Prelini, C. E. With additions by Charles S. Hill, C. E. 150 diagrams and illustrations. Cloth, . . . 3.00

Forwarded postpaid on receipt of price.

"COMPRESSED AIR," 26 CORTLANDT ST., NEW YORK.

EMPIRE AIR TOOLS.

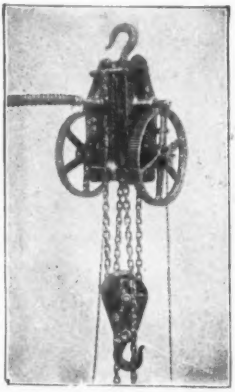
NO. O BREAST DRILL.

All Working Parts Incased.
Gears Run in Oil Chamber.

An important feature which is found in NO OTHER pneumatic drill is an oil chamber enclosing the gears and bearings, allowing them to travel in oil, and avoiding wear, friction and frequent oiling.

No. 00 Drill, Capacity 3/16 in. weight 5¼ lbs.
No. 0 Drill, Capacity 7/16 in. weight 10½ lbs.
No. 0 Extra Drill, Capacity ¾ in. weight 15 lbs.
No. 1 Drill, Capacity 1 in. weight 35 lbs.
No. 1 Extra Drill, Capacity 1¼ in. weight 49 lbs.

PNEUMATIC MOTOR HOISTS.

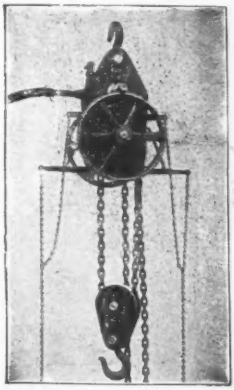


DIFFERENTIAL HOIST.

Take little head-room.
Light, easily handled.
Not dependent on air pressure to sustain load.
Made in following Capacities: Differential, Class "A" Hoists 1,500, 3,000, 5,000 and 10,000 lbs. Friction Brake, Class "B" Hoists, 800, 1,500 and 2,500 lbs.

Our goods are used by the
U. S. GOVERNMENT
in all NAVY YARDS
in the east.

Send for Illustrated Catalog.



FRICTION BRAKE HOIST.

EMPIRE ENGINE & MOTOR CO.,

OFFICE AND WORKS: ORANGEBURGH, N. Y.

CHAS. G. ECKSTEIN,

MECHANICAL ENGINEER,

Berlin, C., Germany. Spandauerstrasse 16-17.

Makes it a specialty to sell

Pneumatic Tools and Appliances

and

Compressed Air Machinery in General,

in Europe.

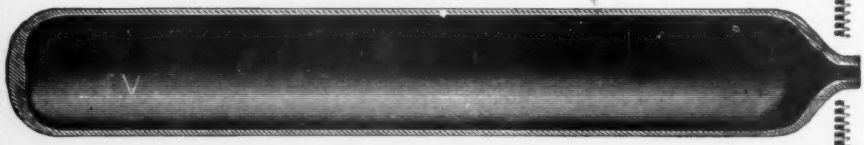
American Manufacturers of

FIRST CLASS TOOLS AND MACHINERY

in above line, seeking an effective representation abroad, are respectfully invited to correspond with the New York Office, 249 Centre Street.

Seamless Rolled Steel Tubes

FOR GASES, COMPRESSED AIR, ETC.,
UNDER HIGH PRESSURE.



In lengths up to 24 feet.

Manufactured in Germany after the famous *"Mannesmann Process."*

Tested and approved by the highest authorities and Governments of Europe and America.
Each Tube is carefully tested, and a Government Test Certificate is furnished with same.

Representative:

Chas. G. Eckstein,

249 Centre Street, New York.

CAMERON STEAM PUMPS

SIMPLE
COMPACT
DURABLE

Special Patterns adapted for Heavy Duty in all Work.

Thoroughly Tested and Guaranteed.

BUILT FOR EXACTING SERVICE.

NO OUTSIDE VALVE GEAR.

Easily Started. Easily Stopped. No Dead Centres.

Our NEW 112 page catalogue will interest you, FREE.

A.S. CAMERON STEAM PUMP WORKS

FOOT OF E. 23RD ST. NEW YORK CITY.

PUMPING! WATER, OTHER FLUIDS AND SEMI-FLUIDS BY COMPRESSED AIR

THE HARRIS SYSTEM FOR MINE STATION PUMPING

Pneumatic Engineering Co.

SYSTEMS DESIGNED FURNISHED AND INSTALLED.

WRITE US AT. 128 BROADWAY, NEW YORK.

COMPRESSORS

FOR AIR AND GAS,
TO MEET ANY SERVICE CONDITIONS,
STANDARD OR SPECIAL.

IMPERIAL COMPRESSORS

ARE ILLUSTRATED AND
DESCRIBED IN A BOOKLET—FREE.

RAND DRILL COMPANY,

128 BROADWAY, NEW YORK.

Compressed Air.

OR

THE COMPRESSED AIR MAGAZINE.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

W. L. SAUNDERS, J. E. QUINTERO, M. E. VARIAN, - - Editor and Proprietor, Associates

Subscription, including postage, United States, Canada and Mexico, $1.00 a year. All other countries, $1.50 a year. Single copies, 10 cents.

Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

All communications should be addressed to COMPRESSED AIR, 26 Cortlandt St., New York.

London Office, 114a Queen Victoria Street.

Those who fail to receive papers promptly will please notify us at once.

Entered as Second-Class Matter at the New York N. Y., Post Office.

VOL. VI. FEBRUARY, 1902. NO. 12.

A book has recently been written on compressed air by Mr. Gardiner D. Hiscox, M. E., which is entitled to special notice. This is an octavo volume of 820 pages and with 545 illustrations, the largest publication we have seen on this subject. Mr. Hiscox is an engineer of large experience, the author of several books on scientific subjects, and a man whose ability is recognized by all who know him. For what may usually be considered a lifetime Mr. Hiscox was the chief mechanical engineer of the firm of James O. Morse, on John street, New York. This firm, though now extinct, was one of the most reliable machinery houses in the East. Later on Mr. Hiscox entered the employ of The Ingersoll-Sergeant Drill Company as engineer, and in this capacity he was brought in close contact with compressed air appliances at the time when air compressors and pneumatic tools were beginning their development.

"Compressed Air; Its Production, Uses and Applications" is the broad title to Mr. Hiscox's book and a glance at its pages convinces us that this title is not an exaggerated one. The work is the most comprehensive of any heretofore published on this subject. It is, moreover, the most practical and valuable work on compressed air and is a cyclopedia of information on this subject. Mr. Hiscox is always clear and practical in his descriptions. He does not follow the course of so many engineers and writers, of beginning in the middle of a subject and assuming that a great many things are or should be understood and taken for granted. The elementary nature of this work is one of its most valuable characteristics. The mathematics of the subject are well, and, we think, sufficiently treated. What the reader wants is practical results that have been deduced from fundamental rules or stated in tables and diagrams by capable engineers. He cares nothing for the arguments or the calculations through which these things have passed, but he wants some authority for a rule or table and there is no better one than Mr. Hiscox.

The subject is treated in the beginning by a historical sketch giving us the use of air in moderate conditions of compression and stating a historical fact generally unknown, that the use of compressed air for mechanical purposes "antedates any knowledge we possess of the use of steam by many generations." The statement is made that more than two thousand years before the Christian era, air under pressure was used in the reduction of metals from their ores and in the forging of iron and steel. This sketch is the most complete and detailed history of compressed air that has heretofore been pub-

lished. Beginning with the physical properties of air, the subject is treated from a vacuum to its liquid form, and useful tables, extracted from reliable works on this subject, are given. Such elementary and yet important subjects as "Air in Motion and Its Force," and "Air Pressure Below Atmospheric Pressure" are given at length with practical illustrations of evaporating apparatus, vacuum pumps, etc. The power of the wind is treated to even the extent of a scientific analysis of the kite and windmill. Even the "Ball Nozzle" is analyzed and explained. The theory of air compression is a very broad one which plunges us at once into the intricacies of thermodynamics. Mr. Hiscox spends but little time on this subject, important though it certainly is in connection with our knowledge of compressed air. Isothermal and adiabatic compression are briefly treated, and the well-known diagrams and tables are published. No attempt is made to introduce anything new in this line, but a very successful effort has been made to set forth plainly what has heretofore been accepted as authoritative. The theory and practice of the air compressor are plainly stated and many illustrations are given taken from the designs of well-known American manufacturers. In the brief treatment of the subject of transmission, sufficient information is given to aid the engineer in properly designing a plant. As a matter of fact we know very little from a standpoint other than a theoretical one about compressed air transmission. The usual installations extend moderate distances and where there has been an occasional transmission of a mile or more, the volume of air is usually small because of the expense in piping incurred where large volumes are carried. Engineers do not recommend large compressed air distribution plants where the air is carried long distances, except where the conditions favor its use as against electric transmission. The rock drill, pneumatic tools and other air-using devices are treated at much length and in a progressive and fair spirit. The work ends with a brief chapter on liquid air, a subject which will always interest the scientific mind.

This book should find its place as a reference in the libraries of those interested in the subject, and with some alterations, mainly in the line of condensation, it should be a valuable text book for schools and colleges. There is some evidence of haste in its preparation, to which we have no doubt Mr. Hiscox will give attention while preparing a second edition. There is also, we think, too great a tendency to spread the matter out. Smaller illustrations, condensation of type and omission of blank pages would make the book less bulky without detracting from its value.

Rock Drill Enlarging Windows in the Court of U. S. Treasury.

The frontispiece of our present issue is a novel illustration of another application of the modern rock drill, which is of interest to our readers as a machine which may be driven equally well with steam or compressed air. In the present instance it is being run by steam because this medium was at hand. The picture shows a rock drill mounted on a temporary platform drilling horizontal holes in the tough granite sills of the court windows of the United States Treasury building at Washington, D. C.

We are indebted to Mr. Jas. L. Parsons, of Washington, D. C., for this photograph and information. Mr. Parsons also tells us that he has used drills for similar work in drilling out brick. The idea may suggest other applications of rock drills, and if any of our readers can produce a photograph to equal this we will be very glad to receive it.

Compressed Air Haulage Plants.*

BY RICHARD HIRSCH.

When we speak of a compressed air haulage plant, we include the entire installation required for the operation of compressed air locomotives. This equipment consists of compressor, storage tanks, pipe line, charging stations and locomotives, which are frequently termed air motors. In the above, I have omitted the track system and cars. Generally, these are already installed and operated by animal or other power, which compressed air supplants as a more efficient and economical method of doing the work.

GENERAL DESCRIPTION OF PLANT.

A steam driven compressor discharges into a storage tank or battery of tanks, but more frequently directly into the pipe line. In the latter case the pipe line is made of sufficient capacity to act as a storage reservoir. When the conditions are such that the locomotive can be charged at the power house, make a round trip with the train and return to starting point without recharging, storage tanks may be used. They are located in the power house near the compressor, and no pipe line, properly speaking, is required. When the length of haul is considerable, trains heavy, grades against loads, and other conditions exacting, it becomes necessary to charge the locomotive at both ends of the run. This requires a pipe line, which is made of sufficient diameter to perform the double service of storing and conveying the air, and tanks are dispensed with. The line is laid on the surface parallel to the tracks, and in mine installations, runs through the mine entries. Frequently the line runs from the power house and down the mine shaft before reaching the working levels.

The air line is of lap welded wrought iron pipe, and varies from 3 to 6 inches in diameter, depending upon the amount of storage required. Joints are made by heavy threaded sleeves which have an annular caulking groove at each end, into which a strip of soft metal can be driven to stop leaks, should any occur. At intervals of every three or four hundred feet, a bolted flange joint is placed for convenience in making lateral extensions to the system, or to meet other contingencies where it might be necessary to open the line. These joints consist of a pair of heavy cast iron flanges, into which the pipe is screwed with a tapering thread, and the end of pipe beaded over. The principal feature of this joint is the soft metal gasket, which is of wedge shape section with the taper toward the center. The flanges have finished faces, one male, one female, and when bolted together leave an annular groove of proper shape to receive the gasket. When the bolts are drawn up tight, the metal is forced toward the outer edge, completely filling the cavity, and making a joint perfectly tight under pressures as high as 1,000 pounds per square inch. All tees, crosses, elbows and other fittings are provided with flange ends as described.

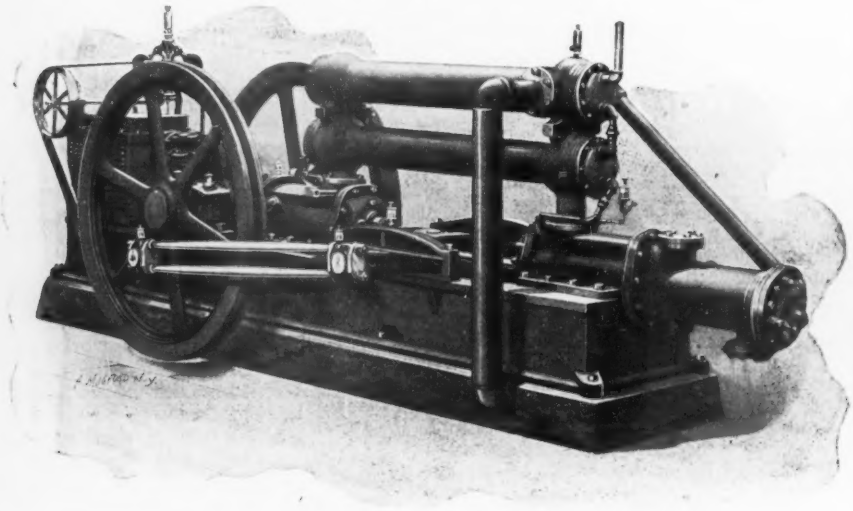
The charging station consists essentially of a cast tee with flange outlet, a 1½ inch gate valve, and three 1½ inch metallic ball joints. The latter are connected to the gate valve by short lengths of extra strong wrought iron pipe, the whole forming a very flexible metallic coupling that is absolutely tight under all working pressures. The coupling terminates with a brass nut which fits the check valve on the air tank of the locomotive. The flexibility of this coupling is such, that no exacting precision is required in stopping the locomotive for charging, a range of a foot or more forward or backward being allowable.

The entire operation of charging, including stopping, making connection, and getting under way with train, consumes but one or two minutes, and this is usually at the terminals of the road where there is generally a lay-over of some considerable time before starting on the return trip. We thus have a perfectly free and independent motor, unrestricted in its movements. Before passing from the subject of pipe line, it might be noted that where the diameter of pipe is slightly more than three inches, the cost of pipe line and tanks of like capacity is about the same; where the diameter is large, the difference in cost is in favor of the pipe line.

*Abstract of a paper presented before the Engineers Society of Western Pennsylvania and reprinted in its Proceedings for December, 1901.

THE COMPRESSED AIR LOCOMOTIVE.

The general construction of the compressed air locomotive is about the same as of those operated by steam, so far as the machinery is concerned, or as we might say, the engines proper. In other words, all parts, such as frames, valve motion, cylinders, rods, spring rigging, et cetera, differ but slightly from the like parts of the steam locomotive. These parts, however, are made of more liberal proportions than has been the practice in the building of steam locomotives, of the same size, making a stronger and more durable machine. The principal difference consists in the substitution of air storage tanks in place of the steam boiler and its accessories. These vary in number, capacity and strength, as the work requires. Usually two tanks are used, resting upon saddles which are supported by the engine frames. They are necessarily very heavy for carrying high pressures, and on a fairly large motor, would run from fourteen to sixteen feet in length and about forty inches outside diameter. Shell plates, ⅞ inch thick; heads, 1¼ inch thick. Circumferential seams are double riveted lap joints, and the longitudinal seams are butt joints with inside and outside welt strips. The longitudinal seams have eight rows of rivets, spaced to make a joint 85% of the strength of the solid plate. Rivets are 1⅛ inch and 1¼ inch diameter driven in drilled and reamed holes. These tanks would carry a pressure of about 700 pounds per square inch, and using plates having a tensile strength of 60,000 pounds per square inch, have a factor of safety of three and one-half. This is an ample margin, as the tanks are free from all the strains of expansion and contraction, to which a steam boiler is subjected. The heads are flanged, dished to a radius of about three feet, and set in the tanks with the convex surface outside, a construction requiring no bracing. The front head of the tank is provided with a manhole which is reinforced by a heavy cast steel frame, and closed by a cover of the same material. The tanks are coated inside and outside with a specially prepared paint to prevent rusting,



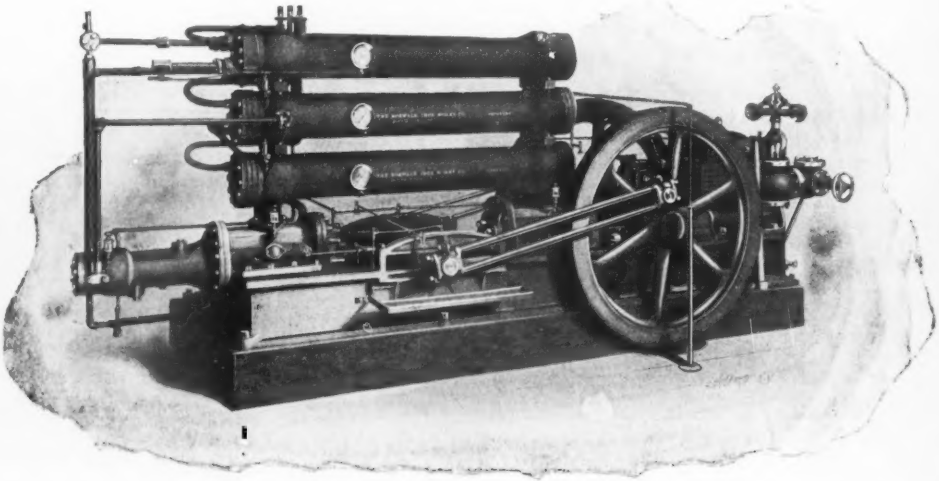
Three-stage locomotive charger. 450 cubic feet of free air per minute. Pressure 900 pounds per square inch. Built by the Norwalk Iron Works Co., South Norwalk, Conn.

and there being no other cause for deterioration, they last indefinitely, and no renewals or repairs whatever are required.

Use has also been made of lap welded wrought iron tanks with heads brazed into the shell, but of much smaller diameter than the riveted tank just described. For exceedingly high pressures, nests of seamless steel tubes may be used; these are about nine inches in diameter, and carry a pressure of 2,000 pounds per square inch.

Each locomotive tank carries a check valve fitting the charging station coupling; through the reducing valve without further loss in pressure. The auxiliary reservoir usually consists of a piece of 8 inch or 9 inch wrought iron pipe, from 10 to 12 feet long, and closed at the ends with cast steel heads. It relieves all fluctuations in pressure which the operation of the engines might cause, and produces a uniform working of the mechanism in the reducing valve. The distribution of air in the cylinders is controlled by a Stephenson link motion of the usual locomotive type, and the air is used expansively.

This description applies in a general



Three-stage locomotive charger. 375 feet of free air per minute. Pressure 2500 and 900 pounds per square inch. Built by the Norwalk Iron Works Co., South Norwalk, Conn.

communication between the tanks is effected by means of a connecting pipe, and the motor may thus be charged from either side. The air, before entering the cylinders, passes through an automatic stop and reducing valve into an auxiliary reservoir, and then through a balanced throttle valve into the valve chests. A constant working pressure of from 140 pounds to 150 pounds per square inch, is thus maintained, so long as the pressure in the main tanks exceeds or equals this amount. When the pressure in the large tanks falls to this point, the air passes

way to all air motors, but such a variety of conditions is encountered in this work that no two machines of different plants are alike. Some idea of these varying requirements may be gathered from the fact, that these locomotives have been built in sizes running all the way from a 5 in. x 10 in. to 12 in. x 18 inch cylinder, and weighing from 9,000 pounds to 45,000 pounds. They have been restricted in height to 53 inches, and in width to 39 inches, and gauge of track has been as narrow as 18 inches. The number of tanks may vary from one to three, and

in some cases, where sufficient storage can not be provided on the locomotive, a separate tender is attached and connected to the motor by means of a flexible metallic coupling. These tenders are of the four wheel type, carry three large, high pressure tanks, and add more than 100% to the possible running distance of the locomotive.

The size and type of motor, capacity of pipe line or storage tanks, together with the amount and pressure of air required, are all determined by the conditions met with in any particular case under consideration. Briefly stated, these conditions are, length of haul, weight of train, number of trips required per day, grades and curves in track, resistance cars offer to rolling friction, weight of rail, and the very important item, the clearances for the motor, as for instance, the height and width of mine entry. The weight of train, together with the resistances due to rolling friction, grades and curves, determine the size and weight of locomotive required. Frequently the restrictions in regard to height and width are the determining factors, and when so restricted, the weight of train must be proportioned accordingly. The amount of free air required depends upon the amount of work to be done in terms of foot pounds. The pressure in the motor tanks is governed by their volume and the amount of free air required between charging points, and the tanks are invariably made as large as circumstances permit. The cubical capacity of the storage tanks or pipe line, and the pressure carried therein, must together be sufficient to equalize, in the process of charging, to the pressure required in the tanks of the motor. All of these points, and more particularly the proper reserve to be allowed in the matter of air pressures and volumes, depend largely upon the judgment of the engineer, and a thorough knowledge of all the conditions involved is absolutely essential. Bad alignment of track, light rail and poor rolling stock might upset all calculations, if based in any way upon mere assumption.

AIR COMPRESSORS.

The types of compressors used in air haulage plants are almost as varied as the locomotives. The conditions governing the design of the compressor are, of course, different from those which govern the design of the locomotive. One feature, however, is common to all, viz., the air is compressed in three or four stages before reaching the final pressure.

To illustrate the compounding process of air compression, let us suppose that we are to produce a pressure of 900 pounds per square inch. If we were to attempt this in a single cylinder having a stroke of 15 inches, the piston must travel to within ¼ inch of the end of stroke before the confined air will reach the required pressure. All the air would be crowded into the clearance space without lifting the discharge valves, and will have expanded to atmospheric pressure when the piston has completed its return stroke.

In our illustration we have taken no account of the temperature which would result from such an operation, and we are compelled to use compound compressors for very ordinary pressures, if for no other reason than for the purpose of cooling the air between the several stages of compression. For pressures as low as 100 pounds per square inch, the heat losses are reduced more than one half in a two-stage compressor, and for the higher pressures the saving by the three and four stage machines is very much greater. To derive the full benefit of compounding, the air must be thoroughly cooled between the several stages of compression, and the temperature should be reduced to that of the atmosphere or much lower if possible. By heating the air in the motor cylinders, a large percentage of the heat losses can be recovered, and in compound motors, the air should be heated before each expansion.

Distributing the work of compression in several cylinders tends to equalize the difference between the power developed in the steam cylinder and the resistances encountered in the air cylinders. In a single stage compressor the resistance in the air cylinder is nothing at the beginning, and greatest at the end of the stroke, while in the steam cylinder the conditions are exactly the opposite. This difference between power and resistance must be equalized by the use of heavy fly-wheels. In a multi-stage machine, the final pressure comes in the last cylinder only, which is small in diameter, the intermediate pistons meet pressures proportional to their areas, and the work of compression is thus distributed throughout the stroke.

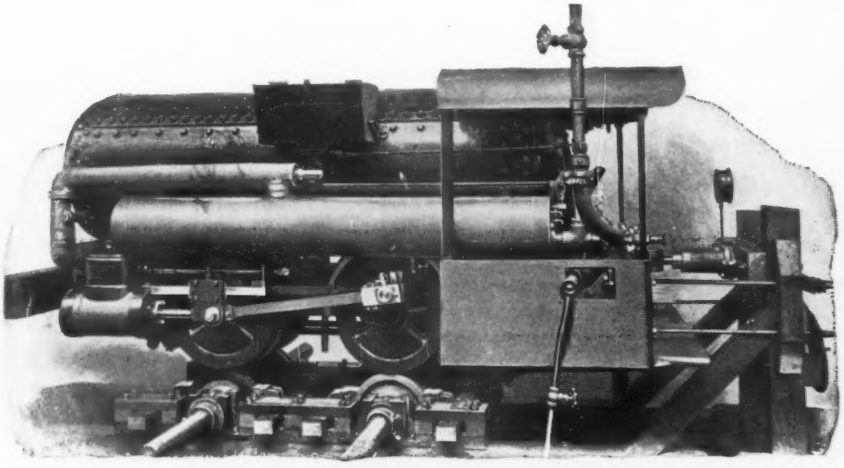
The high pressure cylinder is invariably single acting to avoid the use of stuffing boxes, and frequently all cylinders are single acting. The air passes through inter-coolers between each compression, and all cylinders are surrounded by water jackets.

The steam end of the compressor may be simple, compound or triple expansion, depending upon circumstances. If the cost of coal is high all possible means are adopted to obtain high efficiencies in fuel consumption. The compressor in use at the Anaconda Copper Company's mines in Montana, is a triple expansion Corliss condensing engine, and the steam before entering the intermediate and low pressure cylinders, passes through steam heated receivers. At coal mines where fuel is reckoned at fifty cents a ton, simple engines are generally used.

The power required to compress air to various pressures in single and multi-stage compressors, the decrease in efficiencies due to the rarified condition of the atmosphere at high altitudes, the heat losses in compression, and the economy in inter-cooling, are all found in detail in works on the subject of compressed air and will not be dwelt upon here.

SPECIAL FEATURES OF THE COMPRESSED AIR HAULAGE SYSTEM.

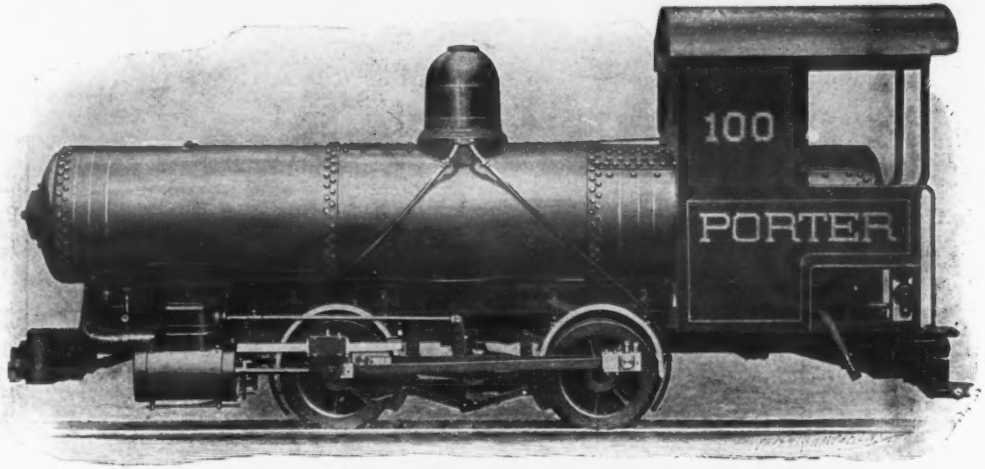
This system of haulage, while used to a greater extent in mining than in any other one industry, has also been largely used in powder mills, cotton warehouses, lumber yards, magazines, et cetera. In these industries, the matter of safety is of paramount importance, and they require a motive power which will assure entire safety from fire or explosion, and which might result from the use of a steam locomotive, or from the sparking wires of an electric trolley system. In these hazardous applications, entire safety is secured by the compressed air system, to the exclusion of probably every other form of motive power. In addition to the feature of safety, mines are freed from smoke and gases which a steam locomotive would produce, and the exhaust air assists the ventilation to some extent.



Apparatus for making shop tests of compressed air locomotives; arranged to ascertain amount of work done with cold and with hot air. The tractive force developed is shown on the dial of gauge attached to oil dynanometer.

Highly charged naked trolley wires in low mine entries, are dangerous on account of the liability of persons coming into contact with them, and the Pennsylvania Report of Bureau of Mines records many such accidents.

While the matter of safety is the most important and valuable feature of the



Compressed air motor used in cotton warehouses. Cylinders 9 in. x 14 in. Gauge of track 36 in. Weight 24500 pounds. Two tanks, combined capacity 160 cubic feet; pressure 600 pounds per square inch. Air heated in hot water re-heater. Built by H. K. Porter Co., Pittsburg, Pa.

compressed air system, in many of its applications, those other qualities, reliability, efficiency and economy are none the less conspicuous.

RELIABILITY.

An air locomotive, when charged, can proceed with its train to the end of the run, and a temporary stoppage of the compressor does not tie up the system. Unless the shut-down is of prolonged duration, the air stored in the pipe line can be drawn upon to keep the system in operation for a considerable time. In such an emergency the pressure would fall rapidly, and after the pipe line would have been drawn upon for one or two extra trips, the pressure in the motor tanks would not be sufficient to make a full trip with train; by placing one or two extra charging stations at intermediate points in the line, the locomotive could be recharged, if it were found that the run could not be completed with the one charge at the lower pressure. Motors are often charged at night and retain the pressure without any appreciable loss until the next morning, ready to begin the day's work.

EFFICIENCY.

Power can not be transmitted long distances as efficiently by means of compressed air as it can be by electricity. This statement applies more particularly when the air is used cold; by heating the air in the motors the efficiency is very materially increased, and when so used the difference between the two systems, in this respect, is not very great. It does not necessarily follow, however, that the compressed air motor is any the less efficient or economical than the electric locomotive. The coal burned under the boilers is not the only item which must be taken into consideration, when determining the efficiency of one system in relation to that of another. But let us give to the word efficiency, a slightly broader meaning than usually attaches to it in an engineering sense. If we define efficiency to mean the amount of money expended, instead of the amount of coal burned to do a certain work, then the efficiency of the air plant will rank high indeed. If we take into account, not only the cost of fuel, but also the cost of operation, maintenance and repairs, we have a very favorable showing.

On account of the simplicity of construction and ease of operation, unskilled labor can very readily be trained to perform the duties of engineer, at moderate wages.

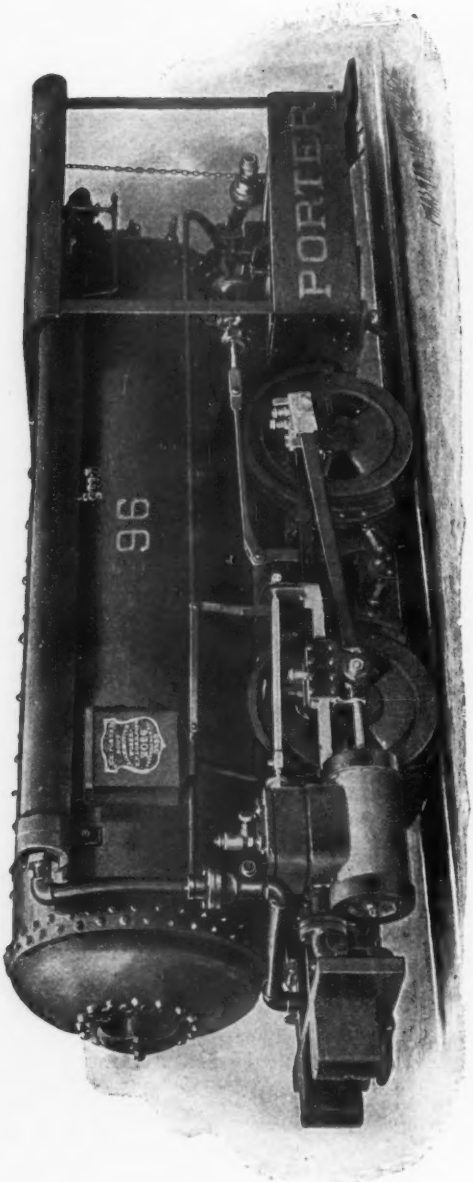
The cost of maintenance, repairs and renewals are small items, as the moving parts are few and suffer but little wear. When renewals are required, such parts can be quickly applied and at moderate cost.

Deterioration is even of less moment, as a very large part of the plant suffers no wear or deterioration whatever, and requires no repairs or attention. The writer has ridden on an air motor that had been under water in a flooded mine for over a year, and the machine was none the worse for the submersion.

Economy, so far as the cost of fuel is concerned, can be increased about 40% by heating the air before it enters the cylinders of the locomotive. The heater consists essentially of a tank of hot water, through which the air passes on its way from the reducing valve to the cylinders, and the heater is charged with hot water and steam at the end of the trip, when the tanks are charged with air. When the air is thus heated, the auxiliary reservoir is dispensed with, the heater being used in its stead and performing its function.

The system can be compounded; but to obtain results which would in any way justify the increased complication, it becomes necessary to heat the air before entering the high pressure cylinders, and again, before the second expansion. These features would greatly increase the complexity of the mechanism of the locomotive, necessitate more careful operation, involve additional wear and renewal of parts, and add to the cost of maintenance accordingly. It would not be advisable to add these complications except, possibly, for street car service, where the run would be exceedingly long and storage facilities limited. The construction of motors for industrial service should be reduced to the simplest possible form, to the end that they are easy to operate and require but little attention to keep in repair.

But simplicity must not be construed to mean crudity. What we might term the refinements of engineering practice, have been sacrificed for purely practical and business reasons, and the number of



Compressed Air Mine Locomotive. Built by the H. K. Porter Co., Pittsburg, Pa., for Commonwealth Iron Co., Cleveland, O. Cylinders 7 in. x 12 in. Gauge 23 in. Weight 14700 pounds. Tank capacity 65 cubic feet. Air pressure 700 pounds per square inch.

successful plants built on those lines have justified that procedure.

Compressed air haulage is not an engineering novelty, and the installations do not consist of a single locomotive in isolated locations, one here, one there. Three or four locomotives are frequently used in one mine; often there are as many as six, and the Anaconda Copper Company in Montana operates nine locomotives in one plant.

COST OF OPERATION.

In order to give some idea of the cost of operation, I will quote briefly from a test made under the supervision of Mr. J. H. Bowden, late chief engineer at No. 6 Colliery, of the Susquehanna Coal Co., located at Glen Lyon, Pa. At this plant, they operate two Porter eight-ton motors, having 7 in. x 14 in. cylinders; tank capacity 130 cubic feet; pressure 500 pounds per square inch. Omitting all details, I will summarize results in a very few remarks.

Total cost of plant, not including steam boilers, cars or track...	$15,156.00
Total cost of operating plant for 179 days including all labor, fuel, supplies, repairs, &c.....	2,202.78
Fixed charges, including interest, repairs and depreciation on plant complete including boilers	1,776.60
Total cost of operation for year 1897, during which the plant was operated but 179 days....	3,979.38
Previous to the installation of the air plant, all coal was hauled by mules, numbering over thirty, and valued at....	4,052.48
The cost of operation by mules, including all labor, supplies, interest, depreciation, &c., for 179 days	11,328.63
Cost of same work by compressed air	3,979.38
Saving by compressed air for 179 days	$7,349.25

At the average rate of saving for the year 1897, the entire cost of plant would be saved in 361 working days.

The average daily work of these two motors for the 179 days, was 1,185 net ton miles. This makes the cost of hauling coal in this plant, under the then existing conditions, less than $1\frac{9}{10}$ cents per net ton mile. The cost of the same work by mule power was $5\frac{34}{100}$ cents. In his report, Mr. Bowden stated that to operate the plant to the full capacity of the two compressors, and for 300 days per year, would bring the cost of operation, including fixed charges, to $\frac{547}{1000}$ cents per gross ton mile, or $\frac{984}{1000}$ cents per ton mile net load.

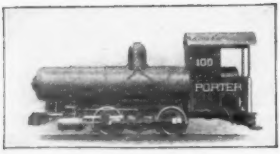
COMPRESSED AIR PLANT AT THE IONA ISLAND MAGAZINE.

The United States Government is, at the present time, building a great naval magazine on Iona Island, in the Hudson River about 41 miles from New York City. This island lies near the west shore of the river, in fact, it extends into the swamps on the westerly side, while on the east it has a deep water front and dockage facilities. The West Shore R. R. crosses the island near its western shore, reaching it through the swamps by trestles at the north and south ends. The tract of land held by the Government comprises an area of about 116 acres, embracing all that part of the island lying east of the West Shore R. R. The magazine, when completed, will consist of a dozen or more buildings, each about 200 feet long and 50 feet wide, and are to be used for the storage of all kinds of ammunition used in the United States Navy.

The main track of the haulage plant is laid out approximately in the form of a circle about 900 feet in diameter, and most of the buildings are grouped within it, which forms, as it were, a belt line. At present there are about five miles of track, including switches and sidings, and will eventually be increased by the extensions now proposed. The buildings are all reached by switches from the belt line, which, in turn, has connection with the tracks of the West Shore R. R. and with a dock on the eastern shore of the island. Ammunition and supplies may be received at the magazine by rail or boat, and will be delivered by Government tugs to the war vessels lying at the Brooklyn Navy Yard or in the harbor. When the vessels are at a distance, shipments can be made as circumstances require.

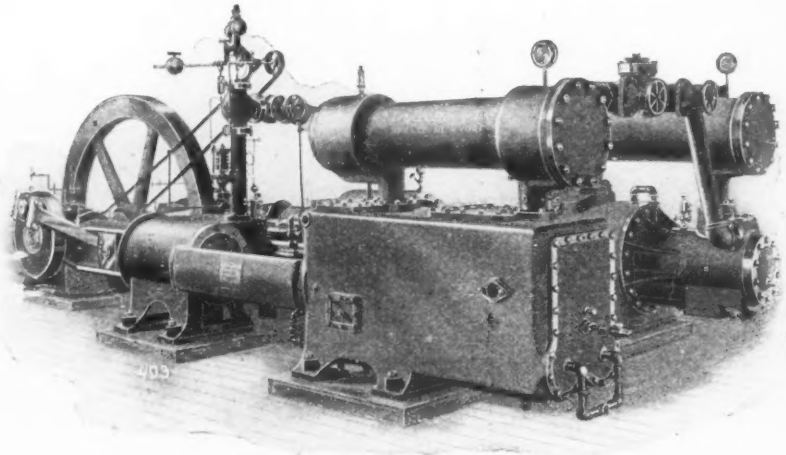
The compressed air locomotive has been in continuous operation since July 27, 1901, engaged mostly in the handling of building material, stone, brick, cement, structural iron work, etc. While the plant is still under construction, and but very little ammunition is stored in the maga-

Compressed air locomotive with tender. One of six motors built for the Cross Creek Coal Co., Drifton, Pa. By the H. K. Porter Co.



zines, nevertheless, steam locomotives from the West Shore road are not allowed to cross the Government property line. When these buildings are filled with explosives, it is superfluous to say that this rule will be rigidly enforced.

The air for this plant is furnished by a three-stage Norwalk compressor having a capacity of 300 cubic feet of free air per minute, compressed from atmosphere to 1,000 pounds per square inch, and in case of emergency the machine can be driven to compress 370 cubic feet at the same pressure. The steam cylinder is 20 in. x 24 in., and for the capacities given above, developes from 70 to 100 horse power. The air intake cylinder is 14 in. x 24 in. with intermediate and high pressure cylinders properly proportioned for compressing to 1,000 pounds per square inch. The air is stored in a battery of six tanks, each 36 inches in diameter and 17 feet long, standing in a vertical position on stone foundations; they have a combined capacity of 650 cubic feet. The pipe line is some 300 or 400 feet in length, 3 inches in diameter, and carries the air to three charging stations. There is one Porter locomotive of the four wheel type, having 12 in. x 16 in. cylinders, and weighs 42,500 pounds. The motor tanks are two in number, 40 inches in diameter, on the left side 16 feet 4 inches long, the one on the right 13 feet 8 inches. They have a combined capacity of 240 cubic feet and carry a pressure of 750 pounds per square inch. This is reduced to 140 pounds in the auxiliary reservoir, and is used cold. The motor is designed to haul two standard loaded freight cars a distance of two miles with one charge of air, and portions of this haul occur on grades as steep as five per cent. The locomotive is capable of exerting a tractive force ranging from 8,300 to 8,900 pounds.



Ingersoll-Sergeant four-stage duplex Class "G" high pressure air compressor, operating Porter locomotives at the rolling mill mines of the Cambria Steel Co., Johnstown, Pa., having cylinders as follows:

H. P. Steam Cylinder, 20 in. diameter by 24 in. Stroke.
L. P. Steam Cylinder, 32 in. diameter by 24 in. Stroke.
L. P. Air Cylinder, 28¼ in. diameter by 24 in. Stroke.
1st. Int. Air Cylinder, 14 in. diameter by 24 in. Stroke.
2nd Int. Air Cylinder, 10 in. diameter by 24 in. Stroke.
H. P. Air Cylinder, 5 in. diameter by 24 in. Stroke.

Pressure 850 to 1,000 pounds per square inch.

DISCUSSION.

Mr. Trinks—I would like to ask Mr. Hirsch what these ribs are for on the cylinders of this locomotive?

Mr. Hirsch—We endeavor to expose a little more surface to the atmosphere for heating purposes. The interior temperature is 60 or 70 degrees lower than the atmosphere, and the ribs on the outside help the efficiency somewhat.

Mr. Connelley—Are the locomotives built compromise gauge or narrow gauge principally? Do you build them for both?

Mr. Hirsch—For mines we have all gauges—anywhere from 18 to 44 inches—and we have built locomotives of all descriptions for over sixty different gauges. At the Iona Island plant they handle cars from the West Shore road, and they are standard gauge, of course.

Speaking of Mr. Connelley's question brings up the matter of clearances also. No matter how low or how narrow the engine, all the machinery must be put in, just the same. We crowd down until we hardly have enough space for the working parts. We have often brought up this question of clearances, and we have been told that to make more room or height for the engine would cost more than the locomotives. Then again the matter of odd gauge: For instance, in the Jones & Laughlins' mills they use 23-inch gauge. Years and years ago they probably bought some second-hand cars somewhere, and the cars happened to be 23-inch gauge. After a while they bought a few more. Finally they bought a little locomotive, a 7 in. x 12 in., weighing probably 17,000 pounds. When they got the locomotive we had to cut it in height and width to get it in on the 23-inch gauge. To do their work now, we are required to put a 44,000 pound engine in the same space the 17,000 pound machine occupied years ago. The same condition exists at Homestead. The first engine used at Homestead was something like a 9 in. x 14 in., weighing probably 25,000 pounds; the last ones had 13 in. x 16 in. cylinders and weighed something like 55,000 pounds. The Jones & Laughlins 44,000 pound and the Homestead 55,000 pound engines are pretty nearly solid masses of metal, and tend to illustrate what we have to contend with. I will say, however, that in laying out new plants the engineers make proper provision for locomotive clearances. If they would apply to locomotive builders for clearances, they would be furnished, only too gladly, with prints and sizes of engines that they may use.

Mr. Whinery—I would like to ask Mr. Hirsch if they experience any trouble with freezing; that is, in expanding the air to 150 pounds into the auxiliary reservoir. I have noticed in coal mine work there was fost around the outlet. Do you experience any trouble with freezing of the reducing valves?

Mr. Hirsch—We have not had any trouble there. We have, in a number of instances, made provision for heating the reducing valve, but it is very seldom necessary. Of course, the air gets cold. One of the photographs I have placed in your hands shows the valve chests covered with frost, due to the condensation and freezing of the moisture in the atmosphere when it comes in contact with the cold surfaces; but on the inside we have no trouble. Of course, we know that the capacity of air for carrying moisture depends upon its volume and temperature, and not upon its pressure. After air has been compressed to probably 1,000 pounds per square inch, it will contain about the same amount of moisture as the same volume of air at atmospheric pressure; and when that air is expanded to 150 pounds per square inch it is very dry, and we experience no trouble with freezing in the cylinders.

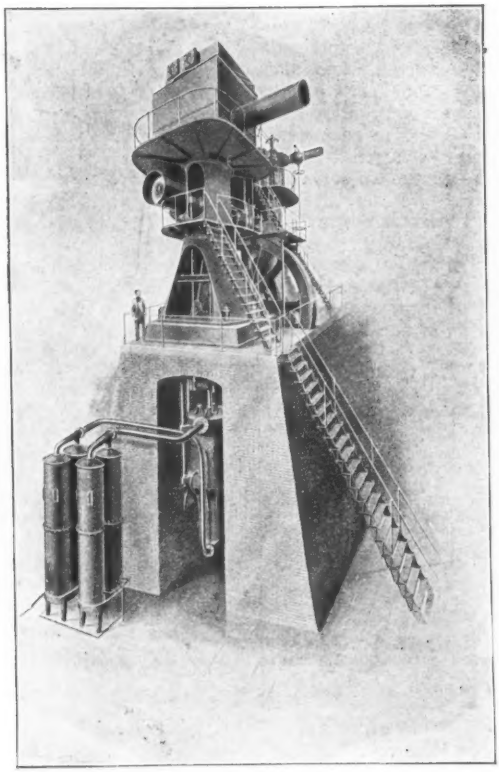
Mr. Whinery—Mr. Hirsch spoke of saving power by reheating. Do you take into consideration the energy required to reheat?

Mr. Hirsch—We have made tests and we find a very great increase in efficiency by using the heated air; it amounts to about 40 per cent., allowance being made for cost of heating. Professor Unwin has stated that the fuel used in heating air is used five or six times more efficiently than if used in a good steam engine.

Mr. Koch—Do you have to use larger ports? Are they larger than they are with steam?

Mr. Hirsch—No; they are about the same size for air or steam; it makes no difference.

A Member—Why do you use the slide valve?



This machine consists of a duplex vertical cross compound engine, built by the E. P. Allis Co., of Milwaukee, and the Ingersoll-Sergeant Air Compressor being of the four cylinder type, has cylinders of the following dimensions.

L. P. cylinder	46	inches.
1st Int. "	24	"
2nd Int. "	14	"
H. P. Cylinder	6	"
Stroke -	60	"

All the above cylinders are single acting.

The free air capacity per revolution is 56.735 cubic feet; capacity at 40 revolutions, 1269.4 cubic feet, and the free air capacity at 60 revolutions is 3404.1 cubic feet. The approximate pressure in first cooler is 40 pounds, in the second 180 pounds and in the third 850 pounds, the final approximate pressure in the after cooler being 2,300 pounds.

Mr. Hirsch—The piston valves leak more with dry air. We have not used them. Of course, we must remember that a piston valve in a steam engine becomes water-packed.

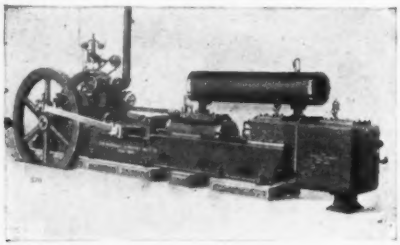
Mr. Koch—On that question of reheating. I use an underground hoist; I run it sometimes with steam, and sometimes with hot air. We have a large pump, and we think it is a pretty good one, when it delivers 800 gallons a minute from the bottom of the mine. We run that with hot air. Sometimes the pipe gets broken, and we can't stop the pump, so we turn on the compressed air. We take the air from the compressor, pass it through a hot water heater, and then raise it to a temperature of 400 degrees by subsequent heating. It goes to the pump and hoist with considerable steam in it, and we can run the pump and hoist about as cheaply that way as we can by steam; in fact, a little cheaper; but then, of course, it means more machinery to look after. But we find this: I have had to enlarge my ports. If we turn superheated air into it there seems to be a drag on it; it does not seem to work satisfactorily. But we enlarged the ports a little, and the enlarged ports will work perfectly well with the superheated air, and they do not seem to affect the steam very much. The air is carried 350 feet away from the compressor to the place where it is heated. On one engine I use a piston valve with superheated steam. She runs a dynamo and runs about 350 revolutions per minute. She gives the best card and is the most economical engine I have.

Mr. Bole—I would like to ask Mr. Hirsch about lubricating the valves and cylinders. When compressed air is used on a locomotive, how do you lubricate the valves?

Mr. Hirsch—On compressed air locomotives we use what is ordinarily called a steam chest oiler; but we use a low gravity oil, and have had no adverse reports in regard to the matter of lubrication.

Mr. S. M. Davis—I am connected with the Atlantic Refining Co., and we are arranging to deliver lubricating oil to the mills in tank wagons. Some of the tanks in the oil houses are often on a level with the tank wagon, and we experience considerable trouble discharging the oil. At one of the mills we tried a rotary pump. I suggested the use of compressed air to force the oil out. I operate a small air compressor by a chain and sprocket wheel attached to the rear wheel of the tank wagon. This compresses air into a couple of small drums at a pressure of 125 pounds per square inch, which passes through a reducing valve into the oil tank at a pressure of 10 to 15 pounds per square inch. The tanks are 36 inches in diameter, 3-16-inch steel, single riveted. I figured I had a factor of safety of six. Would that be sufficient?

Mr. Hirsch—That is rather a novel feature. I am sure I never heard of it. Ordinarily a factor of six is ample; but for such uses as this I would recommend a much larger factor, and would run no risk of getting anything like 125 pounds pressure in that tank, which might occur if the



Three-stage compressor Ingersoll-Sergeant Drill Co. Simple steam cylinder. Horse power 25 to 200.
Capacities, 84 cubic feet to 476 cubic feet of free air per minute. Air pressure 500 to 3000 pounds per square inch.

reducing valve got out of order. For such uses it ought not to carry more than the 10 or 15 pounds.

Mr. Ridinger—Mr. Hirsch, can you tell me what it would cost to run a pipe line of sufficient size to deliver 480 cubic feet of free air per minute, at 100 pounds pressure, at a distance of three miles from compressor?

Mr. Hirsch—To convey 480 cubic feet of free air per minute a distance of three miles, and with a terminal pressure of 100 pounds per square inch, would require a 4-inch pipe, and the loss in pressure would be from 10 to 12 pounds; in other words, the initial pressure would be from 110 pounds to 112 pounds per square inch, and the terminal pressure 100 pounds as required. We must remember, however, that while we lose some 10 per cent. in pressure, we gain in volume, and the actual loss of power in a pipe line as here given, would not amount to more than 3½ or 4 per cent. The line can be made perfectly tight and there need be no loss by leakage. The cost of laying the pipe would be about 3 or 4 cents per foot, depending on circumstances, and the cost of pipe must include freight and delivering to the place where required in addition to the cost of pipe at mill. I have not the latest pipe quotations at hand. This will enable you to compute the actual cost of line.

Mine Locomotives.

Electricity vs. Compressed Air—A Comparison of the Efficiencies and Relative Cost of Installation of the Two Systems.

A very interesting article appeared some time ago entitled "Compressed Air Haulage Plant," and describing an installation at the No. 6 Colliery of the Susquehanna Coal Co., Glen Lyon, Pa. The article in question was a reprint of a paper read before the Canadian Meeting of the American Institute of Mining Engineers in August, 1900, by Mr. J. H. Bowden. A description of the same plant appeared in the *Colliery Engineer and Metal Miner*, of May, 1896. The conditions obtaining in this mine are especially favorable for economical locomotive haulage, all grades being moderate and in favor of the load. General statements regarding the superiority of electricity as compared with compressed air, do not appeal to the technical engineer, and it is necessary therefore to carefully consider a specific case. The requirements as outlined in the above mentioned paper are as follows:

NO. 6 SHAFT.

Haulage road, four thousand (4,000) feet one way.
Grades average 1.5 per cent. in favor of the load, maximum 2¾ per cent.
Total number of cars per 10-hour day, 355.
Average trip, fifteen (15) cars.
Weight empty trip, twenty-one (21) tons.
Weight loaded trip, seventy-three (73) tons.

NO. 6 SLOPE.

Haulage road, twenty-one hundred (2,100) feet one way.
Grades average 1.5 per cent. in favor of load, maximum 2¾ per cent.
Total number of cars per 10-hour day, 320.
Average trip, fifteen (15) cars.
Weight empty trip, twenty-one (21) tons.
Weight loaded trip, seventy-three (73) tons.

It will be noted that the average grade is specified as 1.5 per cent. rather than 1 per cent. as stated in the original article, in order that any error may be on the safe side. The tractive effort per ton against the grade is 60 pounds, thirty pounds for the grade and thirty for the track resistance. The loaded trip requires practically no power, as the grade is sufficient to just about overcome the friction. Each locomotive therefore exerts an average drawbar pull of 1,260 lb. (21 × 60) when hauling a train of fifteen empty cars.

The locomotive in Shaft No. 6 makes twenty-four round trips per day or a total mileage of thirty-six miles. At eight miles per hour, the actual running time is four and one-half hours, leaving five and one-half hours for switching, making up trains, etc.

The size of a compressed-air locomotive is generally determined by the rate of consumption of compressed air, which depends upon the load, length of haul, and the topography of the track. To avoid too frequent charging, however, it was necessary to select a locomotive with large storage capacity, weighing about eight tons. The normal drawbar pull of a locomotive of this size is 3,000 lb., which is obviously much greater than is actually required to haul the loads above described.

Still erring on the safe side we will select an electric locomotive weighing six and one-half tons, the rated drawbar pull of which is 2,500 lb. at a speed of eight

miles per hour. This locomotive would consume in electrical energy thirty-three kilowatts when hauling twenty-one tons on a 1.5 per cent. grade at a speed of eight miles per hour. If this locomotive were to work at its full capacity, as in every day practice, it would easily haul twenty-three empty cars up the maximum grade, namely 2¾ per cent. The regular trip, however, should hardly exceed twenty cars on account of the presumable necessity of starting on a level track, the loaded trip weighing ninety-eight tons. The drawbar pull would be 2,940 lb. (98 × 30) which is well within the momentary overload capacity of the six and one-half ton locomotive. In actual practice the drawbar pull would be less as the train would be started "slack."

The service required of the slope locomotive is obviously much easier on account of the relatively short run, namely, 2,100 feet. This locomotive makes twenty-two trips per day, or a total mileage of 17.5, the actual running time being 2.2, leaving 7.8 hours for switching, making up trains, etc. When hauling the empty cars on a 1.5 per cent. grade at a speed of eight miles per hour, this locomotive would also consume 33 kilowatts, or a total of 66 kilowatts for both locomotives, assuming a load factor of 100 per cent. The kilowatt input of both locomotives at their *full rated loads* would be 106 kilowatts (2 × 53) and, allowing 80 per cent. load factor, a much higher figure than is used in ordinary practice, a generator of 85 K. W. capacity would be required. So large a machine is not needed to meet the actual requirements upon which we are figuring, but the size of the generator should be such that the locomotives may be operated at their full capacity at any future time, as the output of the mine increases. In actual practice, the writer would recommend for this plant a generator of at least 100 K. W. capacity, as experience has shown that the uses of electricity rapidly multiply; the subsequent installation of motors for driving hoists, pumps, car conveyors, coke larries, etc., is almost a certainty.

The total output of this mine is about 2,100 long tons of coal, i. e., 675 cars per day, each containing 7,000 pounds of coal. The shaft motor, however, could very easily handle 480 cars, 24 trips of 20 cars each. Assuming the same running time, viz., four and one-half hours, the slope motor could very easily make 45 trips of 20 cars each and could easily handle 900 cars per day. Both electric locomotives could therefore handle 1,380 cars per day, or 4,300 long tons of coal as compared with 2,100 tons, the capacity of the compressed air plant.

The following comparison of the first costs of the compressed air and the electric haulage plants is very interesting:

COMPRESSED AIR PLANT.

Compressor	$ 2,880.00
Extras for compressor repairs	75.75
Shaft motor	2,743.63
Slope motor	2,918.20
Extras for motor repairs	207.93
Air connections 5″ line (6,000 ft)	2,914.32
Air connections 3″ line (4,000 ft)	1,240.46
Steam connections to compressor	278.27
Material for compressor foundations and house and air-washing box	295.27
Labor on compressor house and foundations and 5″ line, and installing shaft motor	1,183.01
Labor on 3″ line and installing slope motor	46.95
Foster equalizing valves	372.21
Total cost of plant	$15,156.00
Additional compressor recently installed	3,000.00
	$18,156.00

ELECTRIC PLANT.

One (1) 85 K. W., 500 volt, belt-driven generator	$ 1,200.00
One (1) generator panel with rheostat	250.00
One (1) 100 H. P. engine (13″x12″)	750.00
One (1) endless belt	75.00
Two (2) 6½-ton electric locomotives	3,600.00
Feeder, trolley and bond wire	800.00
Insulators and labor	600.00
Steam connections to engines	278.00
Material for foundation for engine, generator and power house	400.00
Labor on power house	1,000.00
Freight, boxing and contingencies	500.00
Total	$9,453.00

In an electric haulage plant it is customary to use a relatively high-speed engine, which would consume per I. H. P. hour, 28 pounds of steam as compared with a consumption of 34 pounds by the air compressor. The most sanguine advocate of the compressed air system admits the low efficiency, especially of the high-pressure air compressor. The air is compressed to a pressure of 600 pounds, but as it is expanded to a pressure of 160 pounds in the auxiliary reservoir *before being used*, it is obvious that the energy consumed in raising the pressure from 160 to 600 pounds is *entirely wasted*. The theoretical horse-power required to

compress 100 cu. ft. of free air to a pressure of 160 pounds, in a three-stage compressor, assuming perfect cooling, is 18 H. P., compared with 29 H. P. to compress 100 cubic feet of free air to a pressure of 600 pounds. The energy lost at this point, therefore, is about 60 per cent. of that required to compress the air to a pressure of 160 pounds. The amount of energy dissipated by the various cooling devices may be appreciated from the fact that if the air were adiabatically compressed to 600 pounds, its temperature would be 1,070° F. It is customary to build compressed air locomotives for a storage pressure of 1,500 and even 2,000 pounds where frequent charging is impossible; obviously the higher the storage pressure the lower the efficiency.

The air compressor load is fairly steady, as the chargings are quite frequent, and on account of the low efficiency of the compressor and locomotive, a boiler capacity of at least 300 H. P. is required, now that the second compressor has been added. Compared with this figure, the electric system with high efficiency generator, motors, and engine would require a boiler capacity not exceeding 150 H. P. The load is so intermittent that the addition to an existing steam plant of any size, of a 100 H. P. engine would require hardly any additional boiler capacity. Any bank of boilers which are not overloaded, possesses in itself a considerable storage capacity. The same statement is true of a separate boiler plant for the haulage system, as the load is very intermittent indeed and the boiler will readily respond to momentary overloads.

The operating expenses of the electric haulage system would not be much less than those of the compressed air system. There would be a considerable economy of fuel, to be sure, but the saving in this respect would not amount to much on account of the low money price of the coal which is burned under the boilers at a coal mining plant. The fixed charges, however, would be *very much* reduced, and as shown above, there would be an initial saving of $8,703, exclusive of the difference in the cost of the boiler plants.

A comparison of the following quotations respectively from the article appearing in the "Colliery Engineer and Metal Miner," of May, 1896, and from Mr. Bowden's paper of August, 1900, is very interesting.

"The capacity of the compressor is 296 cu. ft. of free air per minute compressed to 600 pounds per sq. in. with the compressor running at 100 revolutions. As this quantity is more than sufficient for two (2) locomotives the compressor is operated at an average speed of 40 R. P. M., the speed being controlled by an automatic regulating valve, which allows a speed which is sufficient to maintain the required pressure in the air mains.

"Indicated H. P. at 131 *revolutions* of compressor * * 150 H. P.

"The capacity of the shaft motor is equal to fully double its present work, and the slope motor is working at but about one-third of its capacity (admitted), *while the compresor is doing all that it can* (obviously, considering the 31 per cent. increase above rated speed of 100 revolutions), *and a second one was ordered April 7*, 1900.

It would seem very reasonable to conclude that the original expectations had not been realized, as far as the compressor is concerned.

Referring to the latter part of the article, it is easily understood that if air could be compressed and expanded isothermally the most serious losses in the compressed-air haulage system would be eliminated. By the use of water-jackets, etc., we may approach isothermal compression, and, theoretically at least, isothermal expansion can be secured by heating the air *in the cylinder*. If 50 per cent. can be gained by heating the air *before* it enters the cylinder, i. e., in the auxiliary reservoir, the question arises as to why this was not done instead of purchasing the additional air compressor. Seriously, it is not practical to heat the air on a locomotive, especially a mine locomotive, although reheating has been done in compressed-air traction experiments in Washington and New York. The possibility of gaining 50 per cent. by approaching isothermal expansion does not speak well for the efficiency of the system.

[In order that the above discussion may be fully understood, and since Mr. Bowden, who prepared the paper which is used as the basis of Mr. Clarke's figures, has died since his paper was printed, we have submitted Mr. Clarke's figures to Mr. Bowden's successor as chief engineer of

the coal companies of the Pennsylvania Railroad Co., Mr. R. Van A. Norris, whose answer is appended.]

DEAR SIR:—I return to you herewith the article "Mine Locomotives, Electricity vs. Compressed Air," by Mr. W. B. Clarke. I have made calculations similar to those made by Mr. Clarke, and believe his conclusions to be practically correct as far as they go. But there are other conditions besides economy which have decided us in favor of compressed air haulage; the principal ones being the gaseous chacter of the mines, in which the possible sparking of an electric machine would be a source of grave danger; the simple character of the mechanism of a compressed air locomotive, which is within the capabilities of a colliery plant to keep in order and repair; the advantage of having a considerable radius of action beyond the charging stations, and the beneficial effect of the air on the ventilation of the mine.

As was shown in Mr. Bowden's paper, the cost of power is but a small fraction of the total cost of operation, the saving for even a 50 per cent. decrease in the steam used being but .09 of a cent per gross ton mile.

As an evidence of our entire satisfaction with this method of haulage, I might add that we have just ordered another compressed air haulage plant complete for our No. 1 shaft, Nanticoke, Pa. Yours very truly,

R. V. NORRIS,
Chief Engineer.

W. B. CLARKE, in *Mines and Minerals.*

Heavy Pneumatic Forging Machines, I. C. R. R.

The Illinois Central Railroad is building in its Burnside shops, Chicago, six powerful pneumatic forging machines along the lines of two machines already in operation there which were designed and perfected by Mr. Martin Kennedy, foreman blacksmith, and built by authority of Mr. Wm. Renshaw, superintendent of machinery. The machines are being built in three different sizes, two of each size—the largest having cylinders 24 by 31 inches and will weigh 15 tons, the next having cylinders 20 by 26 inches which will weigh 9 tons, and two small machines with cylinders of 15 by 22 inches, estimated to weigh 5 tons. The two machines now in operation at Burnside are the first of this design to be constructed and the present order for six more tend to show that the economy and practicability of the invention have been completely proven. The possibilities of these machines were recognized by Mr. Renshaw in the beginning, and to him Mr. Kennedy is indebted for the encouragement and aid which has made possible the perfecting of a pneumatic forging machine which will thoroughly fill the need blacksmith shops have felt for an economical tool of such a wide range of usefulness. This extraordinary forging machine or "mechanical blacksmith," as it is not incorrectly termed, has been patented in the United States, Canada, England, Germany, France, Belgium, Russia and Austria.

Of the two machines now in daily operation the smaller, having 20 by 20-inch cylinders, has been in use two years and nine months, while the larger, with 24 by 31-inch cylinders, was completed about one year ago. The first of these has already been described, but the further perfecting of the design, we believe, justifies a description, in detail, of this machine and its application to railway work.

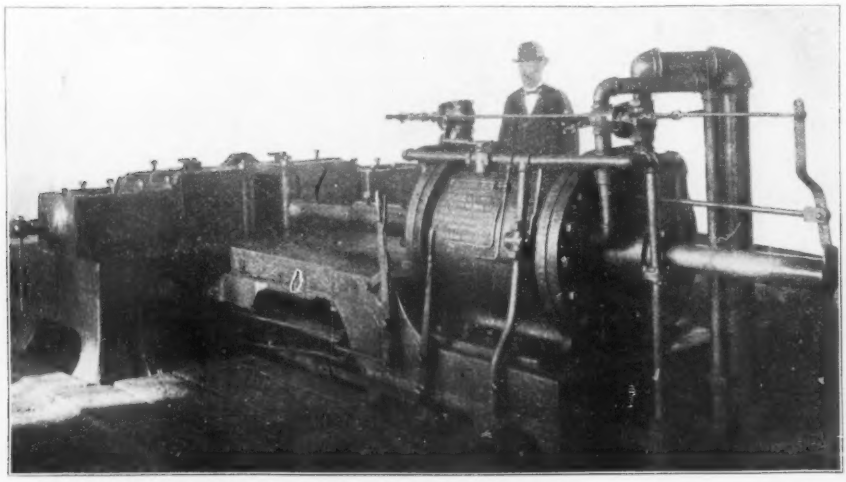
A general view of the machine can be had in the photo engraving, Fig. 1, while Figs. 2, 3 and 4, being plan view, side and end illustrations, respectively, give the details of construction. Further, Fig. 5 shows some of the more important products of the machine and the forging dies utilized in forming them.

The "Mechanical Blacksmith" consists of a T-shaped frame, or bed plate, and is operated by two cylinders, one plunger and one adjustable die. On the longer arm of the bed plate is mounted the 24 by 31-in. air cylinder, the piston of which furnishes the power movement to the bull-dozing plunger. On top, at either side of the shorter arms, are the die-holding forms, which can be set to open and close at any desired distance between them, and one side of which is operated by a lever connecting with the plunger of a 24 by 31-in. air cylinder below (Fig. 4). This machine is designed for a working air pressure of 125 lbs., and some idea of its power will be gained when it is seen that it exerts a static pressure of 57,000 lbs. The rapidity with which the blows can be struck is limited only by the speed with which a man can operate an angle-cock, as the return of the plunger is effected by means of compressed air instead of the usual spring present in other machines; while the capacity of the mechanism for turning out work is restricted only by the amount of iron that can be heated and handled for it.

By reference to the half-tone and the line drawings it will be seen that the piston rod of the cylinder which furnishes power

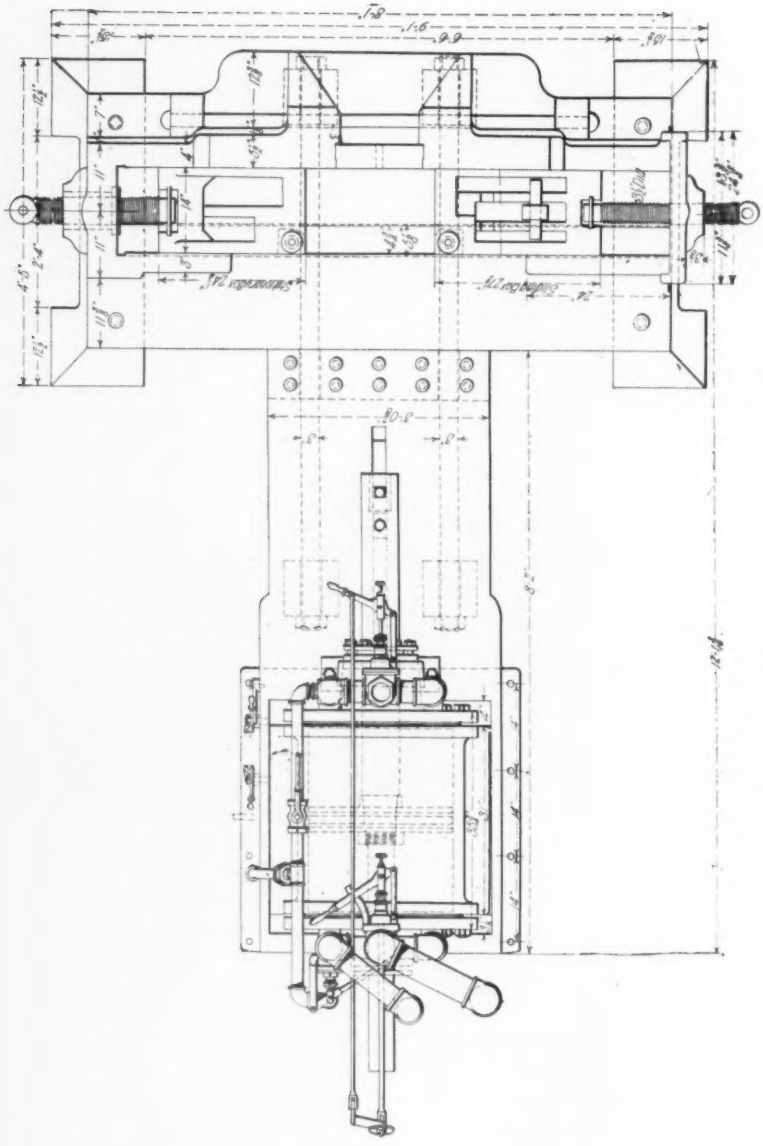
and motion to the plunger, passes through both ends of the cylinder, and on the driving end is a socket for receiving the stems of the male dies, while the other end projects beyond the end of the cylinder to such a distance that when the piston is forced back to the beginning of the stroke, it will operate a lever which opens the exhaust valve, thus causing an automatic control of the exhaust. The die blocks are of a rectangular form and are provided with interchangeable rollers at the two inner corners, which come in contact with the metal as it is forced into the dies. One of these die blocks is connected to the air cylinder shown beneath the machine, as may be seen by reference to Figs. 3 and 4, and is capable of being used as a pneumatic hammer, which greatly increases the range of usefulness of the machine and the amount and character of the work performed. The construction of the dies is made very simple by this arrangement, the dies for nearly all of the complicated operations simply lifting in and out of the forms, and they can be put into place and ready for operation in a very short space of time.

A reservoir is provided for the machine to help out on the pipe line. The hammer piston and die-holding piston can be operated either separately, or in conjunction with each other, while the force of the blow or static pressure in either case can be controlled at will. These adjustments are accomplished by the opening or closing of the cut-out cocks in the line of piping in front of which the operator stands. The disposition of this piping will be seen by reference to the illustrations. To strike a blow with the hammer, the lever-valve just over the right of the cylinder (Figs. 1 and 2) is opened. This admits air to the right side of the cylinder in proportion to the amount the valve is opened; when the blow has been struck this valve is closed and the pressure remains on.

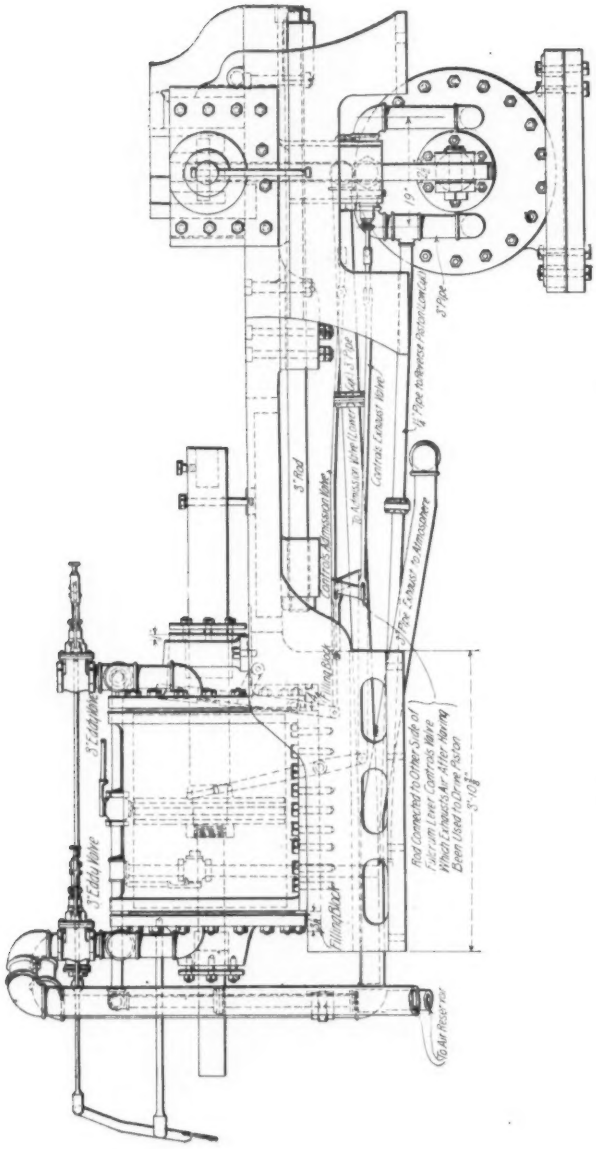


KENNEDY'S MECHANICAL BLACKSMITH—FIG. 1.

The cut-out cocks in the smaller lines of piping having been previously set properly, the air in the cylinder now passes around behind the other side of the piston, and it is forced back to the beginning of the stroke. When the piston shall have arrived at the end of its return stroke the extension of the rod on the right end will strike the trip lever (Figs. 1 and 2), which in its turn pulls open an exhaust exit to the air. The operation of the piston actuating the movable die-holding jaw is made independent or contingent upon this pro-



KENNEDY'S MECHANICAL BLACKSMITH—FIG. 2.

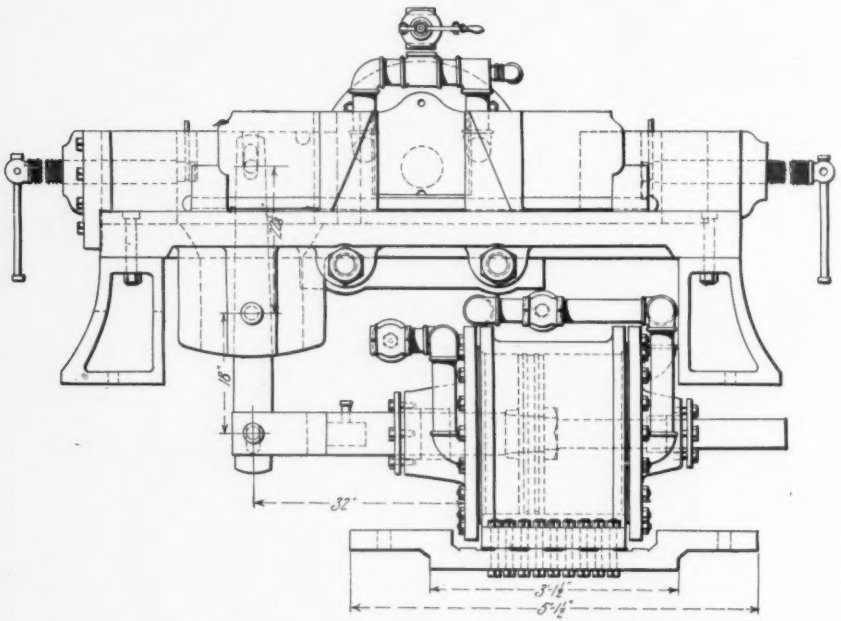


KENNEDY'S MECHANICAL BLACKSMITH—FIG. 3.

cedure by the turning of angle cocks in the large and small lines of piping which run to this cylinder.

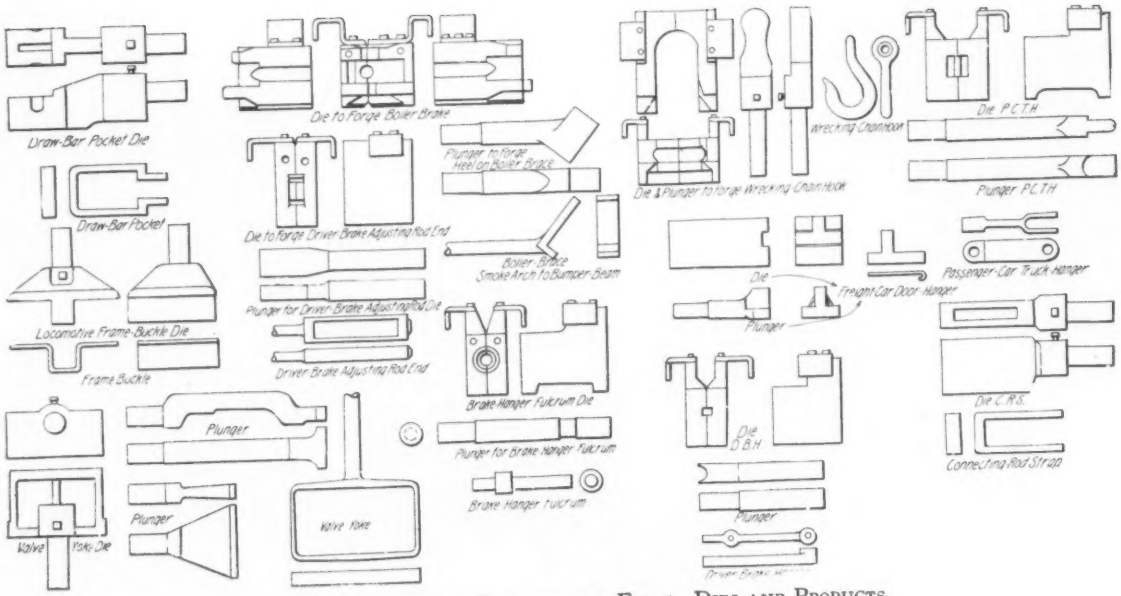
One will be impressed with the wide range of usefulness of the machine upon glancing at Fig. 5, which shows some of its products. In fact, it is claimed that 85 per cent. of locomotive forgings and nearly every job on a car can be turned out without the aid of the blacksmith's hammer, while the terrific blow it strikes has an advantage over a squeeze of the power plete in 5 minutes. Turnbuckles are forged and welded in 2 operations, smoke arch braces in 1 blow, while the thimble or eyelet for rope hoists is bent and grooved in a single operation. From one to three minutes only is required to change the dies necessary in the most complicated jobs, and in every case this can be effected before the metal in the furnace can be brought to the proper heat for working.

In forming needle beam washers and safety straps for body truss rods the die



KENNEDY'S MECHANICAL BLACKSMITH—FIG. 4.

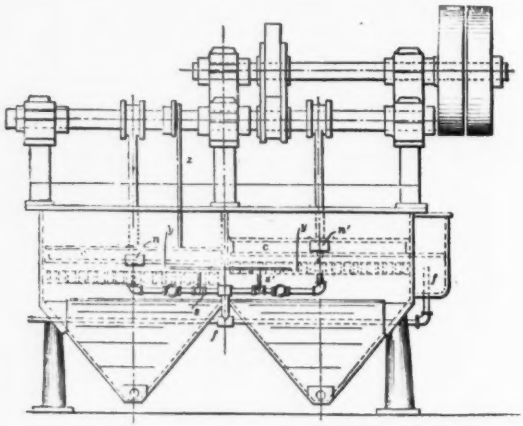
machine, making a more perfect job. Straps, draw-bar pockets, frame buckles, pipe clamps, valve yokes, and the like, of any dimensions, may be made from the same dies by merely applying plates to the faces of the dies of such thickness as will furnish the desired sizes. By placing liners over the face the die used in forming pipe clamps it is possible to forge 30 to 40 different size of clamps in one minute, while a locomotive main rod strap weighing 236 pounds has been forged in 47 seconds, and a valve yoke forged com- blocks are screwed toward the center of the machine and form the sides of a female die, the proper shaped male die attached to the piston rod bending the heated bar around the loosely journaled rollers placed in the front corners of the forms, and forcing it between the dies. In work with four bends the method of procedure is the same, except that the rollers are replaced by filling blocks which give square shoulders to the die forms. In forming draw-bar yokes a two-part die is inserted between the faces of the die-holders, which is



KENNEDY'S MECHANICAL BLACKSMITH, FIG. 5—DIES AND PRODUCTS.

firmly held by their vise-like action, and the bar operated on in three different positions. Riveting and welding operations can be simply performed on the machine by the use of either hammer, and it has the unique capacity of making its own tools.

Mr. Kennedy, the designer of this machine, has spent much time and thought in perfecting it, and Mr. Renshaw has facilitated this by authorizing the making of all necessary patterns and drawings, with the result that a blacksmithing tool has been developed which seems unequaled in simplicity, rapidity, range of application and general efficiency.—*The Railway and Engineering Review.*



THE KLEIN JIG.

The Klein Jig and Classifier.*

BY FERDINAND H. REGAL.

The general form of the jig devised by Mr. John Klein, which is in use in the lead district of Southeast Missouri and in the Phillipsburg district in Montana, is of the inverted pyramid type, resembling the Hartz jig, over which it has, it is claimed, certain advantages.

The use of compressed air plays an important part in the operation of the Klein jig. The main advantages claimed are an increased product, and a cleaner product as compared with that of a machine in which water alone is the concentrating agency. In Fig. 1 the space (f) acts as an air-receiver. An air-pipe (f-f, etc.), leading from this receiver, is run directly under the ore caps below n and n'. The whistle valves, s s', on this pipe, operated through x and y-y by an arm from the rocker shaft, regulate the admission of air. With every stroke of the plunger a puff of air is forced up through the ore cap, effecting a clean and regular output of concentrates through the gates, n and n'. The usual pressure in the receiver varies from twenty-five to thirty-five pounds.

The eccentric can be regulated so as to give a throw of from nought to three inches, according to the class of ore to be treated. In Southeast Missouri, where only galena ore is concentrated, strokes of 0.625, 0.875 and 1.25 inches respectively are employed for material of four, seven and twelve mm. grain; the number of strokes per minute averaging about 150.

At a plant in Southeast Missouri twenty-seven of these jigs, of four compartments each, are treating from 450 to 500 tons of lead ore in twenty-four hours. A test run of several weeks was made on a lot of 2.5 per cent. lead ore, which had been thrown aside; and the net returns showed an extraction of ninety per cent. of the metal at a commercial profit.—*Mining Reporter.*

*Paper read before the American Institute of Mining Engineers, Mexico meeting.

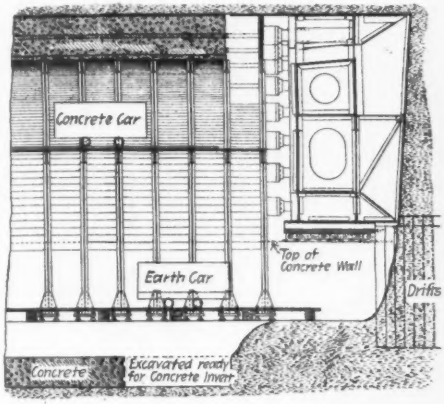
Extension of the Boston Subway.*

The general structural features of the East Boston Tunnel, by which the Boston Subway is being continued to a terminus in East Boston, by means of a submarine tunnel under Boston Harbor, has already been described, and full detail drawings and a general description of the roof shield, which was to be used in connection with a concrete lining, have also been published. At that time no considerable amount of work had been done on the tunnel section proper and nothing could be said of the methods of operation or of their success. The second section of this work, known officially as Section B, is entirely underground tunnel work. This is the portion of the work which alone is referred to in the following extracts, taken from the report of Mr. Howard A. Carson, M. Am. Soc. C. E., Chief Engineer of the Boston Transit Commission:

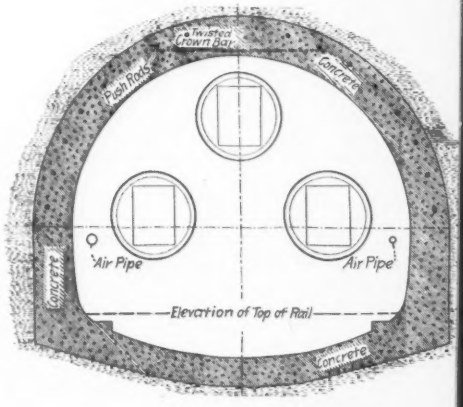
"This tunnel was begun in May, 1900, and about one-fifth is now substantially completed. It is somewhat notable by reason of its size, its projected length under the harbor, and on account of the materials and manner of its construction. Its exterior diameter is about 2 ft. greater and its interior diameter about 1 ft. less than that of the Blackwall tunnel; and its interior diameter is respectively 15 and 20 per cent. greater than that of the St. Clair and Hudson River tunnels. Its length under water is more than twice as great as that of the first named, and is considerably greater than that of the St. Clair or the shield-built portion of the Hudson River tunnel. The ground to be passed through is probably not much more or much less difficult than the clay and silt portions of the tunnels named above. The Blackwall tunnel for a length of about 400 ft. passes through gravel, much more difficult to tunnel through than anything thus far revealed on our work.

"The East Boston tunnel walls, including the upper arch and the invert, have so far been made, and according to present indications, will in the main continue to be made, of fresh concrete, resulting in a monolithic structure. This is believed to be the first successful example of walls made of fresh concrete in connection with shield tunneling. In Paris, concrete blocks resembling cut stone were used to some extent in tunneling for the underground roads, but the attempts there made to use fresh concrete with shields were not successful.

"According to the contract the arch was to be made in two concentric shells, and the shield was to be pushed forward by jacks re-acting against 6-in. lagging on which the outer shell was to be built. As



Longitudinal Section at Shield



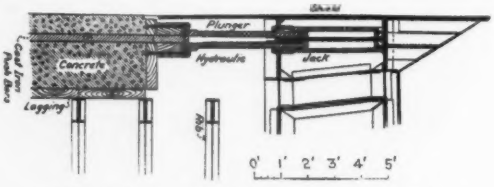
Cross Section Showing Air Locks.

SECTIONS OF EAST BOSTON TUNNEL, SHOWING METHOD OF CONDUCTING THE WORK.

* Abstract from an article in Engineering News, Jan. 23, 1902.

fast as the lagging for the outer shell was taken down it was to have an interior coat of rich cement mortar and the inner shell was to be built against it. The modification alluded to above was to allow the arch to be built of a single thick shell instead of two thin ones, and to use cast-iron push rods imbedded in the arch for the jacks to push against instead of the lagging. A single thick shell is probably stronger than two concentric thin ones, and can be built with considerably less labor.

"This tunnel section is an arched monolithic concrete structure for two electric railway tracks, 20.5 ft. high and 23.3 ft. wide inside. A 2-in. space has been reserved around the interior of the tunnel for applying some treatment to the wall which will give it a more finished appearance. The arch and walls are 32 ins. and the invert 24 in. thick. Pump wells



SECTION SHOWING MANNER OF USING PUSH BARS IN CONCRETE LINING FOR PROPELLING THE SHIELD.

and chambers under the harbor and ventilating chambers on each side of the harbor are included in this section. Refuge niches are built 20 ft. apart in the side walls of the tunnel. The contractors for construction are the Boston Tunnel Construction Co., by assignment from Shailer & Schniglau Co. and Dunfee & Taylor. John E. Palmer is resident engineer for the Transit Commission.

"The apparatus used in the construction work included a roof shield built by James Russell Boiler Works Co., South Boston; weight of shield, without the hydraulic jacks and feed pumps, about 62 tons; diameter of shield, 28 ft. 10 in.; length of shield, 12 ft. 6 in.; hydraulic jacks (for pushing shield), made by Boomer & Boschert Press Co., Syracuse, N. Y.; number of hydraulic jacks, 16, each with a capacity of 75 tons; air-locks built by James Russell Boiler Works Co., South Boston; one high-pressure compressor with a capacity of 710 cu. ft. of free air per min., usual pressure is 125 lbs. per sq. in.; one compressor with a capacity of 1,040 cu. ft. of free air per min., usual pressure is 18 lbs. per sq. in.; one compressor with a capacity of of 528 cu. ft. of free air per min., usual pressure is 18 lbs. per sq. in., furnished by The Ingersoll-Sergeant Drill Co., New York city.

"The high-pressure compressor furnishes power for the machinery, one of the remaining two furnishes compressed air in which to work, and one is held idle as a reserve.

"There are also in use on the work: Three 100 h. p. boilers, 3 air receivers, 1 Carlin cubical concrete mixer, 3 hoisting engines, 1 small engine to run mixer, 1 elevator, 40 small cars, 2 small steam pumps.

"One difficulty anticipated in constructing the concrete tunnel with the use of a roof-shield was that of keying up the arch, by reason of the very small space in which the operation must be performed, and on account of the instability of fresh concrete. A satisfactory method was found which has since been followed, and is described later.

"A shaft, 34 ft. x 36 ft., was excavated at the East Boston end of Section B to the required depth of 42 ft. The concrete invert was then put in, after which the side walls were built up to within 16 in. of the springing line of the arch. The side walls were terminated at this height in order to serve as foundations for tracks upon which the roof shield could run. As soon as the shaft was excavated to the required depth, side drifts 8 ft. square were begun in which to build the walls of the tunnel in advance of the shield. The timbering of the drifts consisted of

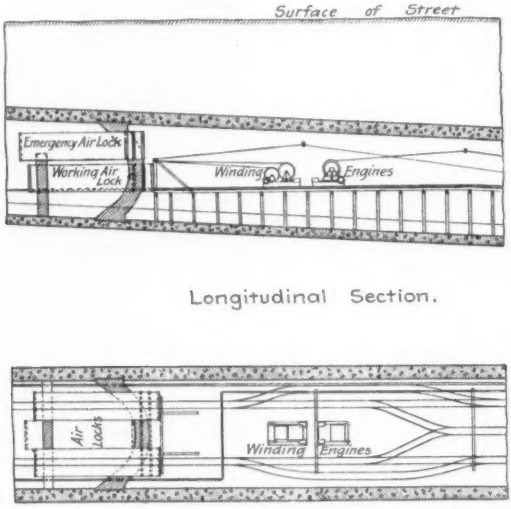
8-in. square spruce caps and 8-in. square spruce legs on the tunnel side of drifts, placed solidly together, while on the outside 8-in. square spruce legs were set 2.5 ft. apart on centers, with a longitudinal 6-in. x 8-in. timber at top and bottom and with 2-in. plank outside.

"When the shield was assembled and riveted 16 hydraulic jacks were placed in the openings prepared for them and connected with pumps also placed in the shield. It rests on 16 live iron rollers, eight on each side, which in turn rest on steel plates placed on top of the side walls. These plates are flanged to act as a guide to the shield when moving. The rollers are 8 in. in diameter and 16 in. long.

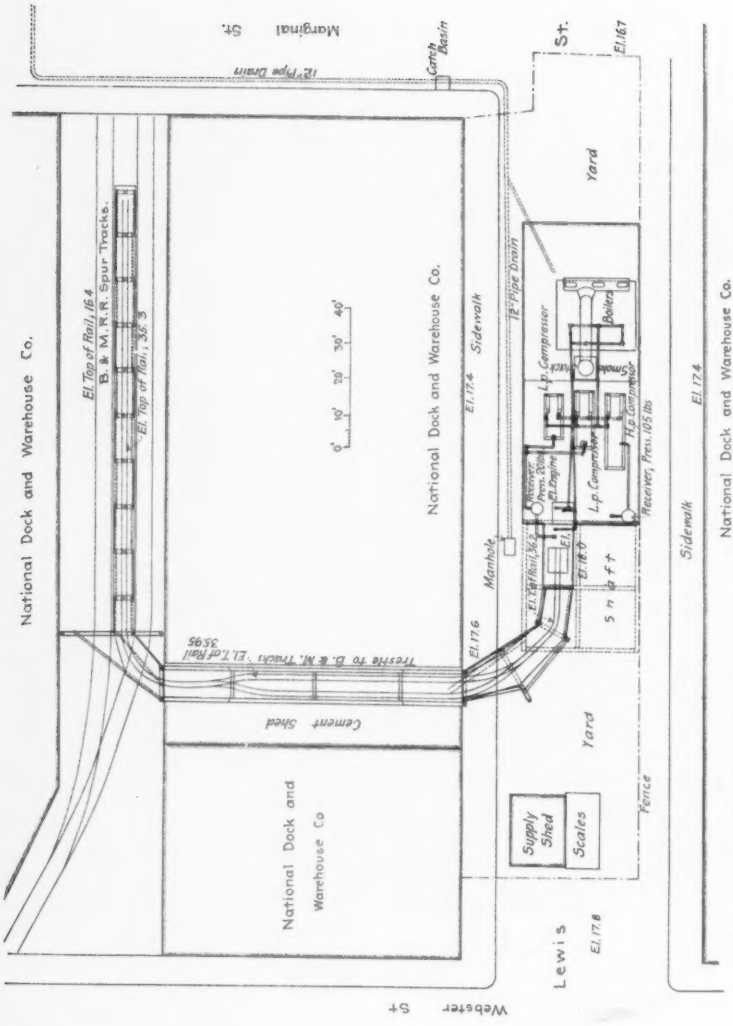
"The shield was forced into the bank to its full length, the interior earth being removed as the shield advanced, and the first arch, 2½ ft. long, was turned. Sixteen lines of iron push rods, each 3¼ in. in diameter, and about 30 in. long, are imbedded in the concrete arch in proper position to receive the thrust of the jacks. Curved steel ribs made of 10-in. channels 30 in. apart are used as centering for each ring of arch. Lagging, 4 in. thick, cut to radial lines, is placed on the ribs as the concrete is put in. Wooden bulkheads attached to the plungers of the hydraulic jacks help to confine the fresh concrete. The final keying up of each ring of the arch is done through two holes, about 13 in. in diameter, originally intended to receive hydraulic jacks, in the rear girder at the top of the shield. As soon as one ring of arch is completed the shield is forced forward 30 in. and another ring of arch is put in. The space left vacant over the completed arch ring by the advancing tail piece of the shield is filled with grout, composed of two or more parts fine sand and one part cement.

"The excavation of the core is done at the same time the arch is being built. The invert is excavated and concreted in 10-ft. sections at a distance of about 20 to 30 ft. back of the shield. The side drifts and walls are kept uniformly about 100 ft. in advance of the shield.

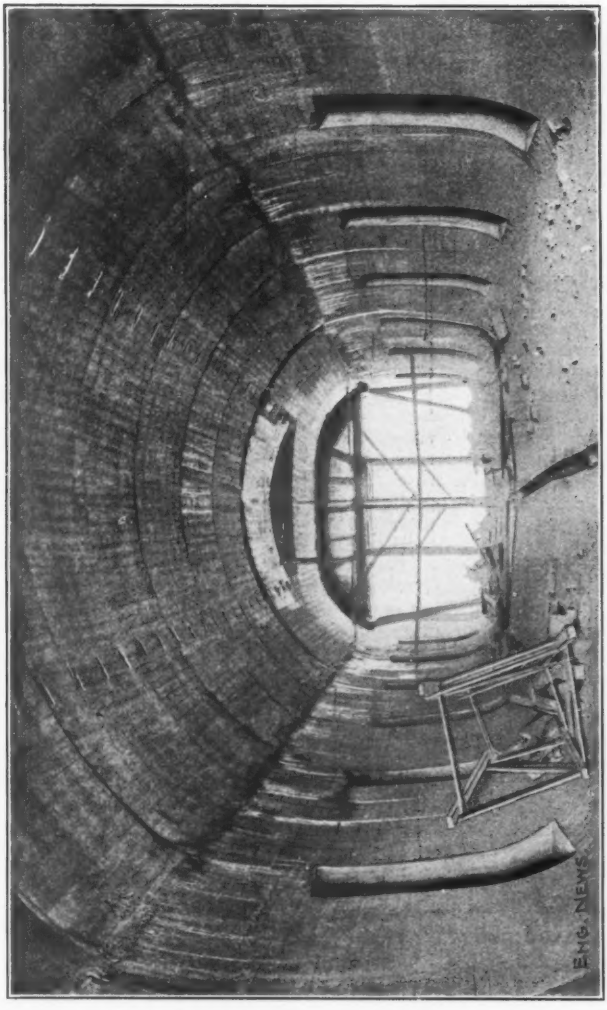
"When the shield had been advanced about 230 ft., work was suspended for



SECTIONAL ELEVATION AND PLAN SHOWING ARRANGEMENT OF UNDERGROUND HAULAGE SYSTEM.



PLAN SHOWING ARRANGEMENT OF POWER PLANT AND SPOIL TRACKS AT THE SURFACE.



VIEW SHOWING INTERIOR OF TUNNEL, WITH CENTERS REMOVED AND CONCRETE LINING READY FOR THE INTERIOR FINISH.

about two weeks to put in the three air locks. Each of these is 27 ft. and 3 in. long, has an internal diameter of 6 ft., is made of boiler iron, and has at each end a tight-fitting door 49 in. high and 39 in. wide. The locks are placed about 110 ft. from the shaft, the two on the sides being about 6 ft. above the invert, and the middle one about 13.5 ft. The two lower locks are used for working purposes, and the upper middle lock for emergency only. A dome-shaped bulkhead of brick masonry, convex on the side of the compressed air, 3 ft. thick, with angle iron hoops, was built around the inner end of the locks, making the tunnel beyond this point a tight compartment in which compressed air could be held without undue leakage.

"For the benefit of non-professional readers it may be stated that an air lock is a sort of vestibule through which men and materials must pass in going from the free air to the compressed air, or in returning. One of its two doors must always be closed to prevent the escape of the compressed air. During the operation of going in, both doors are for a time tightly closed, and by means of valves the air within the chamber is gradually brought to the pressure of the compressed air, when the inner door may be opened. In going out a similar but reverse process is used. The time usually taken by the men in passing through a lock is about one minute. Compressed air was at first used May 5 with a pressure of only 5 lbs. per sq. in. above the atmosphere. This pressure was increased somewhat each day until 18 lbs. was reached. Greater pressure will doubtless be required later. As was expected, the use of compressed air lessened the settlement of buildings and of the street. It also lessened very appreciably the stresses on the drift timbers, caused by the surrounding earth. As soon as compressed air was used the temperature inside advanced to 82° F., at about which point it has since remained. One feature tending to increase the warmth inside the tunnel is the heat produced by chemical action in the concrete —the rise of temperature in the middle of a wall two days after the concrete sets being 40° above that of the air in the tunnel. About 12 days after setting, the temperature has receded to that of the air. The humidity is very high. The greatest amount of carbonic acid gas found at any time in the tunnel has been 69 parts in 10,000. Most of the time it has been found to be from 10 to 16 parts in 10,000. The compressed air is delivered behind the shield, in the top of the shield, and in both drifts. Air escaping through the ground to the surface of the street is very noticeable in rainy weather, making itself evident by bubbles on the pavement. The sound of passing ferry boats and of a pile driver working near by has been plainly heard by men in the drifts.

"The greater part of the excavated material up to Aug. 15, 1901, has been blue clay, weighing about 120 lbs. per cu. ft. For a length of 300 ft. from the shaft, silt and coarse black sand were found near the crown of the arch in a stratum varying in thickness from 1 to 10 ft. Very little water was encountered, and that only near the shaft in the sand and silt stratum just mentioned. This water was drained into a sump in the shaft and pumped out with a small Worthington pump.

"The progress in feet each week since Jan. 26, 1901, is shown by the following table:

PROGRESS DURING WEEK.

Ft.	Ft.	Ft.	Ft.
2.50	30.00	20.00	27.50
10.00	19.08	22.50	25.00
17.50	27.50	20.00	30.00
20.00	17.50	20.00	30.00
20.00	2.50	22.50	30.00
12.50	0.00	22.50	30.00
23.00	10.00	17.50	27.50
27.50	.....	.....	.....

"There are about 22 cu. yds. of excavation per running foot of tunnel and about 8 cu. yds. of concrete. The total force of men ordinarily employed is approximately 140. These are about equally divided between day and night shifts of 11 hours each, working six days per week."

A New Ash and Cinder Conveyor.

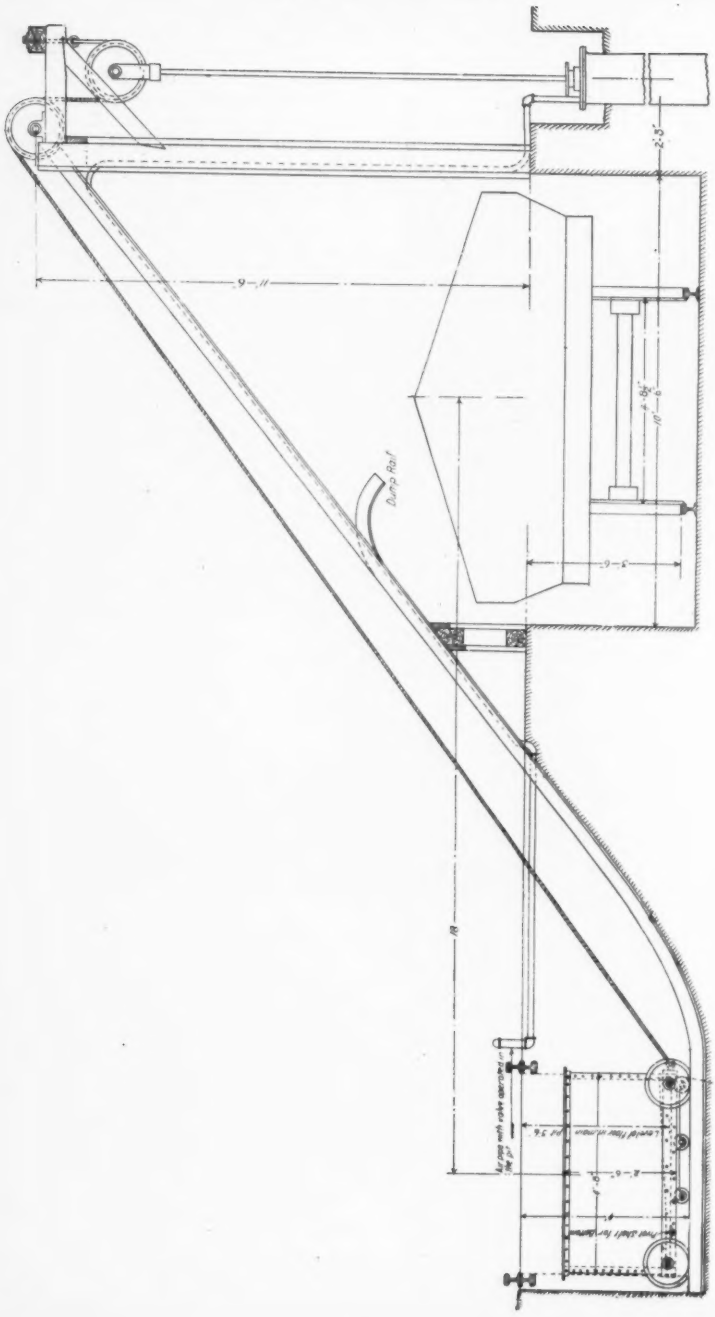
The disagreeable features connected with the handling of cinders in the ordinary cinder pit are such as to cause master mechanics and foremen in charge of roundhouses to welcome any device which will improve on the generally unsatisfactory methods employed in the dis-

posal of cinders taken from engines. A new ash conveyor, simple in design and which will apparently save considerable time and disagreeable labor, has recently been patented. The device, one of which has been placed in service at the Chicago terminal of the Grand Trunk Railway at Elsdon, Ill., is built for the purpose of receiving the ash and cinders taken from locomotives and loading them into cars for removal from the vicinity of the shops. The conveyor, of which illustrations are given of the one now in use at Elsdon, consists merely of a car placed on an inclined track, so laid that the car can be run into the ashpit under the engine, and when filled, pulled out and dumped into a car or other vehicle used for conveying the cinders away. The car used can be made of any size desired to suit the dimensions of the firebox, and is provided with a drop bottom hinged at the lower side of the car. The bottom is held in position by means of small wheels, which run on a third or dump rail, extending from the bottom of the pit to a point over the middle of the car into which the cinders are to be emptied. At its upper end the dump rail is made to curve downward, so that when the car has been pulled up to a position over the receiving car, the support to the hinged bottom is gradually removed, allowing the bottom to drop downward, dumping the cinders.

The power used for the Grand Trunk conveyor for hoisting the cars is furnished by an air cylinder about 9 feet 6 inches long and 18 inches in diameter, and placed in a vertical position. By the use of double pulleys, the car can be pulled up the tracks a distance equal to twice the length of the piston in the air cylinder. As compressed air is now in common use at practically all railroad shops, an arrangement similar to that at Elsdon would probably be used in most cases. Other means, however, such as steam or air, from locomotives, a small hoisting engine, etc., could be employed to suit the conditions at the place where the plant is to be used.

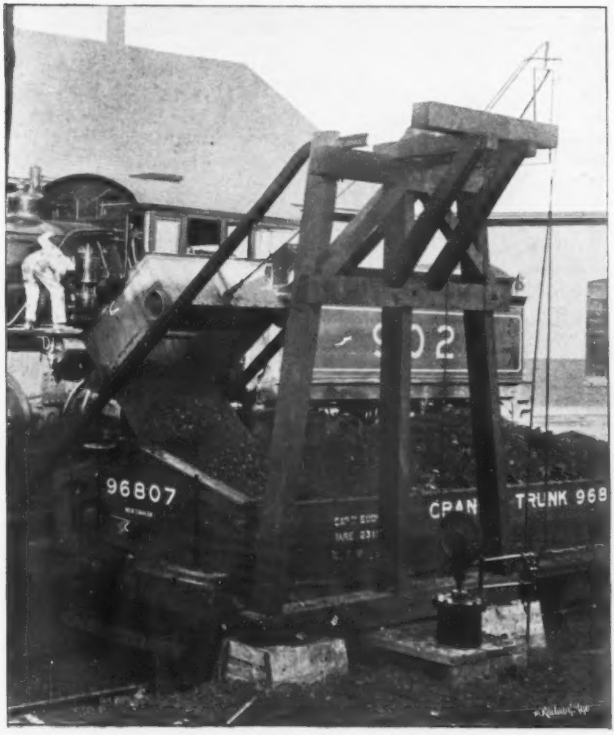
The levers for controlling the cars are placed so that they can be operated by the man scraping out the engine. An improvement, however, will be made to the

CINDER-HANDLING APPARATUS.



PNEUMATIC CINDER-HANDLING APPARATUS.

CINDER-HANDLING APPARATUS.



CINDER-HANDLING APPARATUS.

conveyor by the addition of three way cocks, so that the car will be dumped and will return to position under the engine automatically.

The tracks in the present case are laid on an angle of about 40 degrees, but this feature can be made to suit the layout of the railroad tracks and the space available in different yards. At the shops at Elsdon, by the old method of first dumping the engines and then shoveling the cinders from the pit into the cars placed on neighboring tracks, three men were constantly employed for the work, while with the present device but one man is necessary for the same duties. These facts are given in evidence of the economy and convenience claimed for the device.

The new conveyor was designed and patented by Mr. W. Robertson, master mechanic of the Grand Trunk at Elsdon, who, together with Mr. J. H. Glendenning, 1561 Monadnock building, Chicago, will build the conveyors and place them on the market.—*Railway Age.*

Early Pneumatic Tires.

In view of the remarkable efficiency of pneumatic tires for road vehicles, from their first modern introduction, it seems extraordinary that the original invention of them should have been allowed to drop out of sight, the more so as it seems to have given very satisfactory results.

In August, 1846, considerable excitement was caused amongst fashionable loungers in one of the London parks by the appearance of a brougham with most extraordinary wheels. They appeared to have tires of remarkable dimensions, but the oddest thing was, that the vehicle, though quite as large and heavy as others of its class, seemed to float along the road with an easy bounding movement, yet absolutely silent. Nothing could be heard but the horses' hoofs. The phenomenon was found to be due to an elastic tubular ring of caoutchouc or gutta-percha, enclosed in a leathern case and inflated with air to a considerable degree of tightness. The brougham continued in use, and very soon had covered over 100 miles with these tires, without sustaining any damage to them, although even newly macadamized roads had been run over at times. In the course of the next six months or so more than 1,000 additional miles were run, the tires remaining in excellent order, and the outer sheathing entirely verifying the truth of the old saying, "There's nothing like leather." Experiments made in Regent's Park, March 17th, 1847, with carriages weighing each 10½ cwt., fitted one with the pneumatic, the other with ordinary tires, gave the following results: On a smooth, hard macadamized road the actual draught of the rubber tires was 28 lbs., of the iron tires 45 lbs., a saving in power of 60 per cent. Over new broken flints these figures became respectively 38½ lbs. and 120 lbs., or a saving of 310 per cent. Similar experiments made a few days later over the same ground, with the same vehicles but by different investigators, gave on the smooth road 28 lbs. to 43½ lbs., and on the rough 35 lbs. to 115 lbs. In the latter case the greater difference in results was supposed to be due to the rough flints having been a little worn down during the few days' interval. Only a common spring dynamometer was used to measure the tractive force, although much more delicate instruments for the purpose even then existed. The discovery that ease of draught could be promoted by using tires of a yielding material was considered almost more remarkable than that such substances as leather and india-rubber could stand the wear and tear of carrying vehicles over common roads. Contemporary drawings show a circular-fronted brougham fitted with tires some 4½ in. in diameter externally when fully inflated. The carriage has no springs, the tires being considered to remove the necessity for them—in itself a tribute to their efficiency.

The mode of construction of these tires was as follows: A thin flat iron tire, ⅛ in. thick and 4 in. wide, was first placed over the felloe, to bind the wheel together and afford a foundation for the pneumatic arrangement. A strip of leather about a foot wide was put around this, and upon that another metallic tire, thinner and narrower than the first. These three tires were then secured by large-headed screws or bolts passing through them and through the felloe, and secured on the inside of the latter, so that they could not draw out. Next, an india-rubber tube was placed in position, and over that another strip of leather, riveted one side to the overlap of the first leather belt, and laced to it on the other.

Means for inflation were, of course, provided. A nipple formed on the tube projected about half way through the felloe, a small tube tied into it passing quite through and projecting sufficiently to admit of a brass cap being screwed on the end upon a leather washer, to make an air-tight joint. A metal collar sunk into the felloe served to keep the pipe in its place. The "condenser," or air pump, used seems to have been almost identical with the modern ones now familiar to most people.

The wheels in question, which are known as the "patent aërial wheels," were invented and patented in 1846 by Mr. Robert William Thomson, of Adam Street, Adelphi, London, civil engineer, whose patent is No. 10,990. It seems singular that so successful an invention should have dropped out of sight for many years. As London was then paved with granite setts or large cobble stones, though macadam was largely used in the newer parts of the town, the comfort and saving in wear and tear of such wheels must have been far beyond what we now realize from using them on wood pavement or asphalt.—*The Engineer.*

A Good Air Pump Record.

Engine No. 1720, on the New York Central Railroad, has been running between Buffalo and Dewitt, N. Y., equipped with a New York No. 2 air pump, which ran thirteen months, about eighteen hours out of twenty-four every day, excepting at times when the engine was held in for light repairs and being washed out.

There were no repairs done to the pump, except packing at intervals of about two to four weeks. The service on this line is what we consider rather severe on air pumps, as from sixty to ninety and as high as 100 cars are coupled in one train, and there was a great amount of leakage, which usually exists in trains of this length.

This engine was run by several different engineers, who are deserving of a great deal of credit for the manner in which the pump was run. A small amount of graphite was put in the air cylinders when the pump was new, and at no time was there more steam turned on the pump than was required to maintain main drum pressure, as well as being started slow, which prolongs the life of an air pump to a very great extent, especially on high-pressure engines of to-day.

The condition of this pump when overhauled was fairly good, excepting the packing rings to the air cylinders, and air valves were worn not to exceed one-quarter inch lift.—*William Owens, in Railway and Locomotive Engineer.*

Notes.

The International Steam Pump Company has acquired control of the Clayton Air Compressor Company.

We understand that there is an impression current that the Standard Pneumatic Tool Co. was included in the recent pneumatic tool combination. This is not correct.

The Magnatite Foundry Company, St. Louis, Mo., is making a number of improvements at their plant. A new core oven is being installed, the foundry is being fitted with track facilities, the electric equipment and the lines supplying compressed air are being extended.

A compressed air drill can be kept from freezing by use of the warm discharge water from the mine. A one-quarter inch pipe attached to the exhaust ports of the drills and the warm water piped into them will keep them free from frost, though half a mile from the source of supply.

At the Wachusett Reservoir for Boston's new water supply, a 1,000 h. p. air compressor plant has been installed by the Rand Drill Co., to supply power for the quarry, as well as the work on the dam, which are both several miles away. Large wrought-iron pipes carry the air and all the hoists, drills, etc., are operated by it.

The Economy Locomotive Sander Company, manufacturers of the Economy pneumatic track sanders, 805 Fidelity building, Baltimore, Md., have reorganized with a capital stock of $300,000, under the same name. The officers are: President, James M. Coale of the Coale Muffler

and Safety Valve Company of Baltimore; vice-president, John Hanway of New York City; treasurer, Frank W. Coale, and secretary, John S. Bridges.

Work has been started by the Nordberg Manufacturing Company on the removal of its works from the present plant on Virginia street, in Milwaukee, Wis., to the new shops in the town of Lake, Wis., several miles south of the location of the present plant. The shops at Lake include a main building 120 by 200 feet; a second shop 100 by 240 feet; pattern storage building 80 by 150 feet, together with an office building, engine and boiler house, etc. The present plant represents an outlay of about $350,000.

Men were hoisted in a jiffy to the seventh story of the Bair & Gazzam building, on Third avenue, Pittsburg, in the test of a new extension ladder recently bought by the City Fire Department at a cost of $9,700. The ladder is a telescopic affair, and is operated by compressed air to a height of eighty-three feet in a second. The purpose of the truck is to rescue people from burning buildings, and to send men and hose quickly to the top stories of a building. It is the only one of its kind in this country.

Tests of compressed air brakes on an electric street car were recently made in St. Louis on the line of railway owned by the city and connecting the water works pumping stations at Baden and at the Chain of Rocks. As reported by Mr. E. A. Hermann, M. Am. Soc. C. E., Sewer Commissioner of St. Louis, the results of the test were as follows:

Speed of car, miles per hour.	Distance required to stop, ft.	Speed of car, miles per hour.	Distance required to stop, ft
25	120	10	25
20	100	8	15
15	60		

From the time of Sir Isambard Brunel and the Thames Tunnel, various forms of shield have been tried, especially in America; but previous to Mr. Greathead's undertaking on the City and South London Railroad, no great advance has been made. The tunnels in this case were 10 feet 2 inches to 10 feet 6 inches in diameter, and the greater part of the line was more or less subaqueous. Where the material was so wet as to require it, the work was done in compressed air. Owing to the remarkable absence of disturbance caused by the shield-driven cast-iron tunnel, this system is now being largely used in similar deep-level tunnels, even where no water is to be met with.

Interesting experiments were made last autumn in St. Petersburg harbor in the raising of sunken vessels by means of air-bags of a new pattern. The bags are made of sail cloth covered with a thin waterproof coating. Each bag is capable of raising a burden of about 17 tons, whereas the bag with all its appurtenances only weighs 1 cwt. The bags can be pumped full of air in thirty to sixty minutes, according to the depth of the sunken ship. The latest experiment reported was made on the 5th of November last, in the presence of a number of naval experts, when a hull weighing 10,000 poods was raised from a depth of 27 feet by the aid of six bags, in thirty-five minutes.

A large foghorn is to be placed in the Gulf of St. Lawrence. The horn is 4 feet in diameter at the outer end and 12 feet long, and the sound is produced by driving compressed air through a double set of valves carrying revolving discs with holes cut in them. One set of discs produces a deep roar, and the other a shrill shriek. The valves are controlled by clockwork, and every two minutes a roar is emitted, followed ten seconds later by a shriek. To operate the horn there are three air tanks, each 6 feet in diameter and 12 feet long, and three oil engines run three compressors to fill these tanks. On a favorable day this horn can be heard at a distance of 12 to 15 miles. The plant is automatic.

Scientific American, in speaking of the various types of automobiles, goes on to say that another interesting motor is one which makes use of compressed air, the air being compressed by a kerosene oil engine carried on the carriage, and superheated by being circulated within the cylinder jacket. Theoretically this motor should show excellent economy, since the compressed air being used before it cools off, the heat of compression is not lost, and the

air in circulating around the oil engine cylinders takes up much of the heat of combustion and transforms it into useful work at the axle. The progress of the industry in this country, as shown at the recent Automobile Exhibition in this city, was extremely gratifying; the form and finish of the American-made machines compared favorably with the very best work of the old, established European makers.

The *Milwaukee Sentinel* and *Milwaukee Journal* of the 14th contain interesting information concerning the newly organized American Compressed Air Cleaning Company, incorporated in Wisconsin this week with a capital stock of $300,000, the incorporators being Frank J. Matchette, proprietor of the St. Charles Hotel, Milwaukee, and president of the Wisconsin State Hotel Association; Niels A. Christiansen of the Christiansen Engineering Company, and Elias H. Bottum, attorney.

The *Journal* heads its article "Suit for Millions," and states that it is claimed the St. Louis company is infringing on the patents of the new company by using the so-called Thurman patents, which are, according to the American company, an infringement upon the patents of William E. Nation of Kokomo, Ind., which the American company owns.

Four kinds of power are distributed completely throughout the works of the Risdon Iron Co., located in San Francisco, Cal.—they are compressed air, hydraulic, steam and electric. Compressed air is used for hoists, drills, riveters, caulkers and other pneumatic tools, the provision for the shipbuilding and repairing plant, wharves and fitting out slip being especially complete. Hydraulic power is used for large riveters, punches, jacks, drop forging presses, hoists, keel plate benders, etc., and also for testing. Steam is used outside the power house itself for steam hammers and heating purposes. The main source of power, however, is electric. Nearly all machines, except the special hydraulic and pneumatic and the steam hammers, which require over 5 h. p., are independently driven by electric motors. The smaller machines are belt driven from line shafts, each having its own motor.

The Philadelphia & Reading Railway Company is preparing to install air engines in its mines in place of the 3,000 mules now used. If the experiment proves a success the other companies will take it up and the mine mule will be permanently displaced. The electric motors in use at some of the mines have not shown the success expected, owing to the expense, and to the danger from the overhead trolley used. While they are still in operation at some collieries, they are not in general use. The compressed air locomotive promises to do the work in a satisfactory manner and at less expense than the mules now used, each engine being capable of doing the work of six mules. The mules are kept in stables in the mines and need much care, which entails a constant expense. Moreover, the large space which the stables take up is the cause of inconvenience, and the introduction of the compressed air motor is expected to prove much more satisfactory in every way.

Mr. W. H. Tew, formerly connected with the American Locomotive Company, Brooks Works, Dunkirk, N. Y., and later with the Mechanical Engineering Department of the Chicago & Northwestern Railroad, has been appointed managing director of the newly organized German branch of the Standard Pneumatic Tool Company, with headquarters at Klosterstr. 13-15a, Berlin, Germany, in which country the Standard Pneumatic Tool Company is about to erect works for the manufacture of "Little Giant" pneumatic tools and appliances for supplying the trade in Continental Europe. They are now purchasing machinery for the plant mentioned, which they expect to have completed before long.

This has been necessitated owing to the unprecedented demand for "Little Giant" pneumatic tools in Europe, particularly France, Germany and Holland, which the company was unable to supply, although they recently greatly enlarged their plant at Aurora, Ill., U. S. A.

Their export business during the month of December, 1901, was 100 per cent. greater than the corresponding month of 1900, and there is every indication that there will be a proportionate increase during the present year.

At the yards of the Central Railroad of New Jersey, at Elizabethport, N. J., the power is distributed by electric current through tunnels running beneath all of the buildings, and connecting them with the power plant, the tunnels being in general 4 feet wide and 6 feet high. Special sets of mains are provided for lighting, for operating the motors in connection with the heating system, and for the operation of the machine tools in each of the buildings. Compressed air is also conveyed through the tunnels to all of the buildings. Large storage tanks are used in the powerhouse, and equalizing tanks 4 feet in diameter and 12 feet long at various points in the buildings, not more than 200 feet apart, to equalize pressures, act as reservoirs and permit the use of pipes of moderate size.

There are two air compressors, each having a capacity of 1,000 cubit feet of free air per minute. In the boiler room are two batteries of boilers, each of 500 h. p., operating on the closed ashpit system, the air being delivered from fans through underground ducts and specially designed bridge walls into the ash pits. The boilers are fitted with shaking grates and burn rice coal. The coal bins are directly in front of the boilers. A single system of conveyors removes the ashes from in front of the fire and discharges them into the ash car, and also elevates the coal from a bin underneath the track into the bunkers. The system is operated by electric motors, and is so divided that it can be used for either purpose without conflict. The stack is of sheet iron, 25 feet high, 5 feet in diameter.

The new United States light-house to be built at Point No Point, Chesapeake Bay, about 75 nautical miles from Baltimore, is of interest from the fact that the usual methods of foundation building for light-houses will be superseded in this case by pneumatic caisson work. The site is in an exposed situation, subject to heavy seas and ice and 15 miles from a safe harbor. The foundation in water 22 feet deep at low tide, is to be carried 22 feet through soft bottom to bearing in hard sand and gravel. The pneumatic caisson will be of timber, 32 feet square and 13 feet high, with a solid deck 6 feet thick, on top of which there will be a cylindrical cofferdam 30 feet in diameter and 51 feet high, with its upper edge 18 feet above high water and just below the first floor level of the dwelling house. The shell of the cofferdam will be made of segmental cast-iron plates in 6¼-foot courses with inside flanges. Excepting in the 5-foot air shaft and four cegmental chambers, which are filled with sand and stone, it will be filled with concrete up to the cellar floor 12½ feet above low water level. The top of the cylinder will be decked with steel beams and brick arches, and will support a two-story and mansard roof octagonal brick dwelling house with a lantern deck and lantern on top. As soon as the caisson is grounded, and while the cofferdam is being concreted, it must be protected by filling in around it 350 tons of 50 to 80-pound rip-rap. The concreting must always be kept above high water level, and, after the caisson is sunk to hard bottom an annular filling of large rip-rap, 5 feet high at the caisson and 40 feet wide, must be made to protect the bottom and fill all inequalities. The work has been planned under the direction of Lieut.-Col. W. A. Jones, Corps of Engineers, U. S. A.—*Engineering Record.*

Cooling water by means of compressed air is an easy matter. The cold, expanded air should only be led through a pipe or coil of pipe dipped into the water to be cooled, and then exhausted into the atmosphere.

The writer can recall a fact of personal experience, when in charge of some tunnel work. A ventilator fan blowing fresh air to the front was actuated by a small steam engine working with compressed air, the exhaust of which was led into a closed chest containing tin tumblers filled with water. On its way to the discharge orifice the current of escaping air was passing along the row of tumblers, and some ten to fifteen pounds of ice were thus daily made quite readily. The miners felt interested in the progress of the refrigeration, and the men of the outgoing shift would seldom fail to dip a dusty finger into some of the tumblers, whose main peculiarity was the existence of a black core at the center of the block of ice.

The air which has done expansive work behind a piston moving in a cylinder escapes at a low temperature and at a moderate speed, and is fit for use as a refrigerating agent. In the air which is simply

released through a valve the whole expansive work is converted into velocity, and almost instantaneously transformed into heat by friction with the surrounding atmosphere or against the neighboring bodies. The result is that no cold can practically be produced in this manner.

Besides, the use of an expansion cylinder coupled to the compressing cylinder reduces to a minimum the actual amount of work required by this process of refrigeration. Its efficiency is low, and it is not economical on a large scale as compared with the ammonia process; but it possesses advantages of simplicity, of cheapness and of safety, which in many cases will make it quite valuable.—*National Engineer.*

The Philadelphia Pneumatic Tool Company will let the contract for their new building on Twenty-first street, below Allegheny avenue, alongside of the Philadelphia & Reading Railroad tracks, in Philadelphia, Pa.

The shop will be one story, with a basement 96 ft. x 130 ft., with side extension for boiler house 24 ft. x 44 ft. The engine room will be located in the basement, where they expect to install an 80 h. p. engine, together with direct connected generating unit for lighting, etc. The boiler will be 60 in. x 16 ft., of the return tubular type, and they will have a round, hollow tile brick chimney 70 ft. in height. The interior construction and roof frame for the building will be of yellow pine, with slag roof. The roof will have four large lanterns or sky-lights, extending transversely of the building, thus allowing plenty of light over the entire floor area. The main floor will be free from partitions except in one corner, where the offices are located.

Mr. Walter Smedley, of the Stephen Girard building, Philadelphia, is the architect.

They expect to occupy the building not later than May 1st, and are installing a considerable number of new machine tools.

This new plant will be easy of access from the central part of the city by train on the P. & R. from the Reading terminal, 12th and Market Streets, to Twenty-second Street station on the Norristown Division, or from Broad Street station to Westmoreland station on the Germantown Division, P. R. R., or it can be reached by trolley cars of the Eighteenth and Twentieth Street lines, which run out Sansom Street.

The shop will be equipped with steam heating plant, modern toilet arrangements, lockers for the men, and everything to make it a complete modern machine shop in every particular.

U. S. PATENTS GRANTED DEC. 1901

Specially prepared for COMPRESSED AIR.

687,773. AIR-BRAKE. Henry F. Noyes, Elgin, Ill., assignor to Westinghouse Air Brake Company, Pittsburg, Pa., a corporation of Pennsylvania. Filed Dec. 19, 1894. Renewed Feb. 27, 1897. Serial No. 625,393.

An automatic air-brake system, the combination, with a train-pipe, an auxiliary reservoir, a brake-cylinder, and a triple valve, of a valve device for controlling the release of air from the brake-cylinder and having connections to the train-pipe, to auxiliary reservoir and to the brake-cylinder, and means connected therewith for retaining a predetermined pressure in the brake-cylinder, whereby the fluid under pressure in the brake-cylinder may be released through the retaining device or directly to the atmosphere by variations in the travel of the piston of the valve device.

687,830. SUBMARINE DREDGER AND GOLD-SAVING MACHINE. John A. Kirk, San Francisco, Cal., assignor of one-half to J. W. Roberts, San Francisco, Cal., and W. T. S. Kirk, Alameda, Cal. Filed May 2, 1900. Serial No. 15,271.

A submarine dredger, the combination of the caisson-chamber, the caisson vertically movable therein, the fixed suction-pipe extending from the chamber into the caisson, the suction-pipe carried by the caisson and telescoping over the fixed pipe, and a pump for lifting the excavated material through said suction-pipes.

687,960. PNEUMATIC ELEVATOR. Frank G. Harrison, Massillon, Ohio, assignor to Williamson R. Harrison, Massillon, Ohio. Filed July 11, 1901. Serial No. 67,843.

A pneumatic elevator, a case, having circular openings in each side, separately-detachable semi-circular plates closing one side opening of said case, one of said plates having a

centrally-located journal-bearing and the other a notch corresponding therewith, arms projecting from the former plate having a journal-bearing at the junction of their outer ends, and a fan and pulley-shaft mounted in said journal bearings.

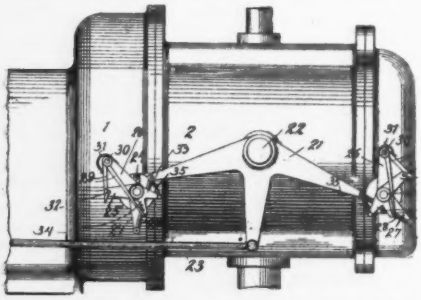
688,004. LIQUEFACTION OF AERIFORM FLUIDS. Oscar P. Ostergren, New York, N. Y. Filed April 14, 1900. Renewed May 17, 1901. Serial No. 60,747.

An apparatus for refrigerating and liquefying aeriform fluid, the combination of a compressor or compressors, a preliminary cooling device or devices for the compressed gas, regenerators in communication with said cooling device, each of said regenerators containing a liquid, a piston adapted to be operated by the liquid in each regenerator, a liquefier in communication with said regenerators, a return from said liquefier to each regenerator, which is adapted to have communication with the liquid in each regenerator, and means for alternately opening and closing of said returns.

688,033. COMPRESSOR-PUMP. Joseph Sloan, Hoboken, N. J., assignor to the General Refrigeration Company, Hoboken, N. J., a corporation of New Jersey. Filed Jan. 18, 1901. Serial No. 43,743.

A compressor-pump, the combination of a divided crank-casing, the upper part of which is hinged to the lower part, a cylinder carried by the upper part of the crank-casing, a piston in the cylinder, an operating-shaft mounted in bearing-boxes carried by the upper part of the crank-casing, a crank on the operating-shaft, connections between the piston and the crank, and valve mechanism.

688,042. FLUID-COMPRESSOR. Frederick C. Weber, New York, N. Y. Filed July 3, 1901. Serial No. 66,967.



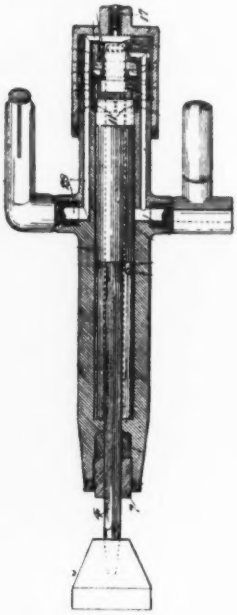
A fluid-compressor, the combination with a compression-chamber and means for compressing fluid therein, and a receiving-chamber, of a combined inlet and discharge valve, having motion in one plane only, valve mechanism for moving said valve from inlet to closed position, and means, actuated by variations in pressure in the compression-chamber with reference to that in the receiving-chamber, for moving said valve to discharge position.

688,135. AIR-SHIP. John Spies, Philadelphia, Pa. Filed Sept. 22, 1900. Serial No. 30,753.

688,182. COAL OR ROCK DRILL. Louis K. Koontz, Allegheny, Pa. Filed March 16, 1901. Serial No. 51,504.

The combination of oppositely-arranged trunnion-supports, an auger-feeding head, and oppositely-curved plates embracing the head and supporting the same against vertical and longitudinal displacement, the curved plate having pivotal connection with the trunnion-supports, and means for varying the frictional engagement of the curved plates with the head.

688,252. PNEUMATIC RAMMER. Julius Keller, Philadelphia, Pa., assignor to Philadelphia Pneumatic Tool Company, a corporation of New Jersey. Filed July 10, 1901. Serial No. 67,711.

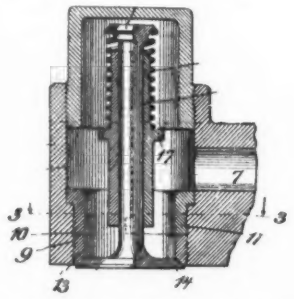


A pneumatic rammer, a cylinder, a distribution-valve therefor, said valve having differential pressure areas, means for directing constant live-fluid pressure upon the smaller of said pressure areas, means for intermittently admitting pressure to the larger area of said valve and an auxiliary port open to live motive fluid after the movement of said valve has been initially affected by said intermittent pressure, whereby an auxiliary supply of live motive fluid is admitted to said valve to retain the latter in the desired position.

688,288. AIR-REGISTER. Charles H. Boeck, Jackson, Mich., assignor to the Novelty Manufacturing Company, Jackson, Mich., a corporation of Michigan. Filed Nov. 16, 1900. Serial No. 36,774.

688,301. AIR-CHAMBER FOR HOT-AIR HEATERS. William E. Goodwin, Manchester, N. H. Filed Aug. 22, 1900. Serial No. 27,671.

688,392. VALVE FOR COMPRESSORS. Hugh V. Conrad, Tarrytown, N. Y., assignor to Rand Drill Company, New York, N. Y., a corporation of New York. Filed Aug. 3, 1901. Serial No. 70,700.



A valve for compressors or the like, the combination with a valve-disk, stem, and stem-head, of a split bushing comprising two members, each having a portion adapted to partially embrace the said valve-stem, and together to form a guide therefor, one of the said members provided with an extension having a valve-seat therein for the said valve-disk.

688,400. PNEUMATIC STACKER. John H. Elward, Peoria, Ill. Filed Jan. 5, 1893. Serial No. 457,328.

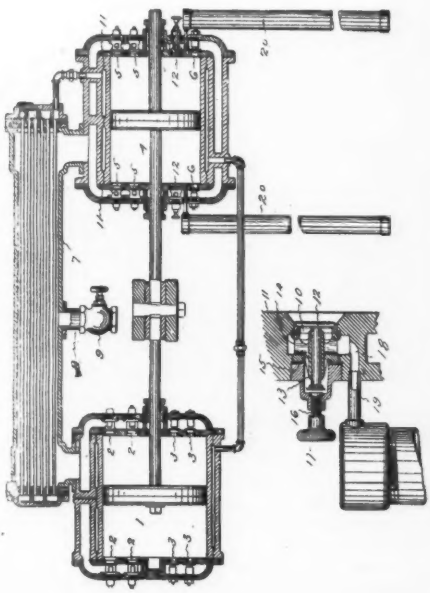
688,434. LUBRICATING DEVICE. Frederick W. Parsons, Elmira, N. Y., assignor to Rand Drill Company, New York, N. Y., a corporation of New York. Filed April 13, 1901. Serial No. 55,763.

A lubricating device the combination with a well adapted to contain lubricating-oil, and a rotatable disk arranged to be partially immersed in the oil in said well, of a scraper, located at a point above the level of the center of the disk, and having one end in contact with the periphery of said disk, the said scraper inclined toward the said disk in a direction opposite to the direction of rotation of said disk, and an oil-conduit in communication with the other end of said scraper.

688,453. AIR OR LIQUID FORCING DEVICE. Abraham T. Welch, Washington, D. C. Filed May 28, 1894. Serial No. 512,785.

A fluid-forcing device, comprising a rotatable or oscillatory vessel, a flexible diaphragm secured within the vessel, openings in the sides of said vessel upon opposite sides of the diaphragm, each opening being provided with means for causing it to act alternately as an inlet and as a discharge, upon the turning of the vessel.

688,520. AIR-COMPRESSOR. Ebenezer Hill, South Norwalk, Conn. Filed Oct. 9, 1901. Serial No. 78,051.



A compound air-compressor having cylinders, pistons, inlet-valves, discharge-valves, interduct between the cylinders, an outlet from the interduct, an auxiliary reservoir connected with the high-pressure cylinder of the pair that are connected by the interduct that is tapped, and a valve controlling the passage from the high-pressure cylinder to the auxiliary reservoir.

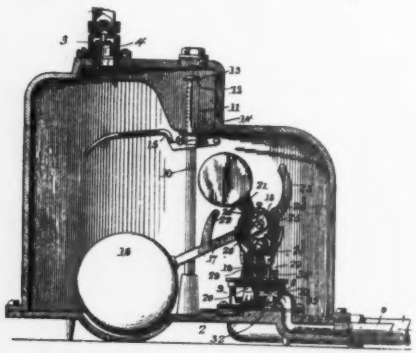
688,559. DUST-ARRESTING BAG FOR PNEUMATIC CARPET-RENOVATORS. John S. Thurman, St. Louis, Mo. Filed June 21, 1901. Serial No. 65,487.

A bag of the character described comprising side and intermediate walls forming compartment-chambers, and a distributing-chamber communicating with said compartment-chambers.

688,563. VAPOR OR HOT-AIR BATH. George W. Weaver, Rochester, N. Y. Filed June 23, 1899. Serial No. 721,663.

688,584. AIR-SHIP. Robert H. Botts, Albuquerque, N. Mex. Filed April 16, 1901. Serial No. 56,109.

688,608. AIR-COMPRESSOR. George Donges, Brooklyn, N. Y., assignor to New York Hydraulic and Steam Pump Company, borough of Brooklyn, New York, N. Y., a corporation of New York. Filed Dec. 24, 1900. Serial No. 40,900.



An air-compressor, the combination with a casing having an air-outlet at its upper end and water inlet and outlet at its bottom, an air-inlet pipe extending within the casing and terminating near the top thereof, valves controlling the water inlet and outlet, and a float adapted to control the movement of said valves, of a sleeve fitted about the inner end of the air-inlet pipe, said sleeve being closed at its outer end and having one or more slots in its side wall, and a lever, connected to said sleeve, fulcrumed on the air-inlet pipe and adapted to be actuated by direct contact with the aforesaid float to so adjust said sleeve as to bring the slots therein beyond the end of the air-inlet pipe.

688,698. VALVE AND INFLATER CONNECTION FOR PNEUMATIC TIRES, &c. Philipp Rupp, Ellwangen, Germany, assignor to Carl Brieger, Hamburg, Germany. Filed April 8, 1901. Serial No. 54,913.

688,810. PNEUMATIC SEPARATOR. Albert Raymond, Chicago, Ill., assignor to the Raymond Brothers Impact Pulverizer Company, Chicago, Ill., a corporation of Illinois. Filed Feb. 5, 1898. Serial No. 669,192.

688,897. PNEUMATIC STACKER. John G. Taylor, Dunrea, Canada. Filed June, 13, 1901. Serial No. 64,371.

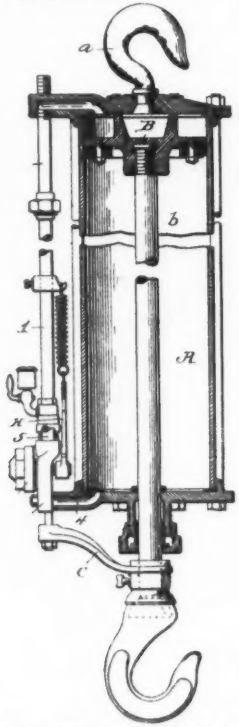
689,043. PNEUMATIC-DESPATCH-TUBE SYSTEM. Edmond A. Fordyce, Chicago, Ill. Filed Aug. 3, 1898. Serial No. 687,586.

A pneumatic-despatch-tube system, a sending-terminal comprising a main tube having two separated valves therein, an air-supply tube having branches which respectively communicate with the main tube at points inward of the valves therein, and a three-way valve controlling the supply to said branches, whereby the air may be delivered into the main tube at a point inward of the inner main-tube valve when said valve is closed, and whereby the air may be delivered at a point inward of the outer main-tube valve and between the two main-tube valves when the outer one thereof is closed and the inner one is open.

689,140. PNEUMATIC HOIST. George F. Steedman, St. Louis, Mo. Filed March 7, 1901. Serial No. 50,243.

An air-hoist, the combination with a cylinder, piston, and piston-rod, of a chambered valve-block in constant communication with the lower end of the cylinder and its valve-chamber, its port leading from the valve-chamber to the upper end of the cylinder, said port being provided with leads on each side and a valve in said chamber for cooperating with said port for admitting and exhausting pressure to and from the upper end of the cylinder, whereby, upon the admission of pressure to the upper end of the cylinder,

said pressure, by reason of the presence of the piston-rod on the lower side of the piston, will preponderate and cause said piston to descend, and a reduction of pressure in the upper end of the cylinder will enable the constant pressure beneath the piston to raise said piston.

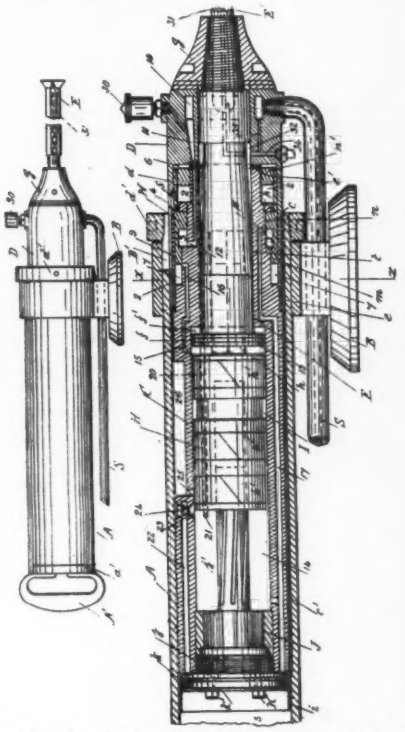


689,229. AIR-VENT. Alfred Roesch, Bridgeport, Conn., assignor to the Davis & Roesch Temperature Controlling Co., a corporation of New Jersey. Filed Jan. 23, 1899. Serial No. 703,032.

A thermostat consisting of a plurality of disks having different coefficients of expansion, and a ring having a low coefficient of expansion for holding said disks together at their peripheries, said disks being arranged first a disk having a high coefficient of expansion, next a disk having a low coefficient of expansion, and so on alternately.

689,516. ROCK-DRILL. Frank Rattek, Bridgewater, Mass. Filed May 2, 1901. Serial No. 58,471.

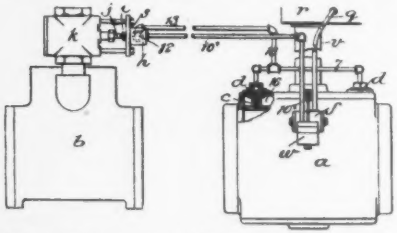
The combination, with a cylinder provided with an annular valve-chamber; of a piston slidable in the cylinder and forming chambers 13 and 14 at its ends; and an annular valve slidable in the valve-chamber and forming a chamber 7 at one end thereof which constantly communicates with the atmosphere,



said valve being provided with a pressure-chamber 3 and an exhaust-chamber 2, and the said cylinder being further provided with a port 16 and a passage 15 which normally connect the chamber 13 with the chamber 7, and having also a port 18 and a passage 17 which connect the chamber 14 with the chamber 3 when the chamber 13 is connected with the chamber 7, said valve operating when reversed to first close the port 16 and then place it in communication with the pressure-chamber 3, and to first close the port 18 and then place it in communication with the exhaust-chamber 2.

689,565. REGULATOR FOR AIR-COMPRESSORS. William Preilwitz, Easton, Pa., assignor to The Ingersoll-Sergeant Drill Company, New York, N. Y., a corporation of West Virginia. Filed Feb. 7, 1901. Serial No. 46,316.

The combination with an air-compressor the discharge-valves of which are subject to fluid-pressure tending to close them, a receiver into



which said compressor discharges and a motor for driving said compressor, of an unloading-valve for said discharge-valves, a regulator for said motor and means controlled by the receiver-pressure for producing first the operation of said regulator and afterward the operation of the unloading-valve.

689,576. AIR-BRAKE. George L. Colledge, Canton, Ohio, assignor of one-half to Charles A. Van Dusen, Canton, Ohio. Filed May 24, 1901. Serial No. 61,677.

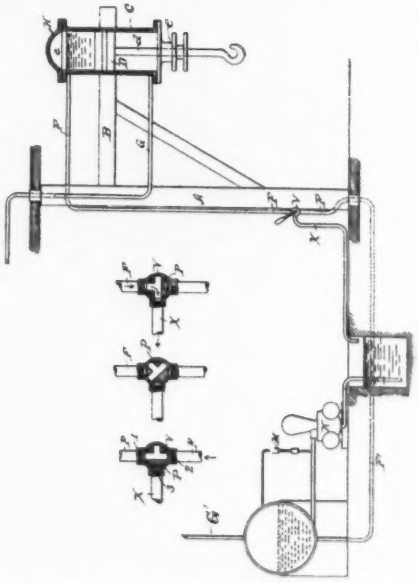
689,702. AIR COMPRESSING AND COOLING APPARATUS. Rudolf Berg, Pittsburg, Pa., assignor of one-half to Ferdinand Wenig. Filed April 9, 1901. Serial No. 55,046.

An air compressing and cooling apparatus, the combination of an exterior casing, a piston-cylinder in the same, open at one end, and constantly communicating at its open end with the interior of the casing, a piston working in said cylinder, valve-chambers communicating with the piston-cylinder and the casing, suction and discharge valves in said chambers; and heat exchangers or absorbers supported one between said valves and the piston-cylinder, and the other between the valves and the casing.

689,800. PNEUMATIC ATTACHMENT FOR BINDERS OR HEADERS. Edward Hafermehl, Guthrie, Okla. Filed March 23, 1901. Serial No. 52,583.

689,918. FLUID-PRESSURE HOIST. George Schuhmann, Reading, Pa. Filed Sept. 23, 1901. Serial No. 76,197.

The combination with sources of compressed-air and liquid pressure, of a hoisting-cylinder having a load-carrying piston therein, the lower portion of said cylinder being in communication with the compressed-air reservoir and the upper portion in valve-controlled communication with the liquid-pressure reser-



voir and with a discharge-outlet and provided with a cushioning-chamber above said liquid communication.

689,923. AIR AND SPRING GUN. Frank A. Simonds, Chauncey H. Fisher, and Hugh C. Ross, Grand Rapids, Mich., assignors to the Rapid Rifle Company, Limited, Grand Rapids, Mich. Filed April 13, 1901. Serial No. 55,781.

689,979. CAISSON FOR REPAIRING VESSELS AND SUBMERGED SURFACES. David Mason, New York, N. Y. Filed Jan. 20, 1900. Serial No. 2,226.

Means for repairing or inspecting the sides and bottom of a floating vessel consisting of a flexible vetebrated water-tight caisson made up of separable sections, the outer surface of which consists of a series of blocks joined together by bolts extending laterally through them, the lateral sides of the caisson being composed of overlapping steel plates secured by the same bolts which hold the separable sections together; in combination with means for causing said flexible caisson to adhere to the side or bottom of the vessel when properly located in position.

690,042. ROCK-DRILL. Governor D. Warren, Independence, Colo. Filed May, 1, 1901. Serial No. 58,382.

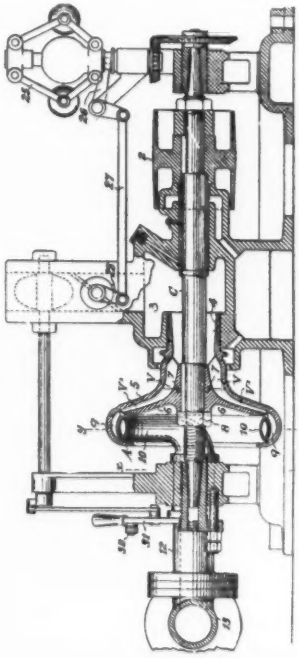
A rock-drill comprising a cylinder, a piston therein, a sleeve surrounding said piston and having ratchet-teeth and adapted to revolve the piston, pawls carried by the cylinder and adapted to allow the sleeve to rotate in one direction and means for preventing the sleeve from moving longitudinally within the cylinder.

690,065. COMPRESSED-AIR BRAKE. Joseph Lipkowski, Paris, France, assignor to Societe Generale des Freins Lipkowski, Paris, France, a firm. Filed Nov. 11, 1899. Serial No. 736,626.

690,084. ATTACHMENT FOR PNEUMATIC CARPET-RENOVATORS. John S. Thurman, St. Louis, Mo. Filed June 22, 1901. Serial No. 65,704.

A pneumatic carpet-renovator or the like, a casing having an open bottom adapted to rest over the carpet being cleaned, means for directing a blast of air into said casing, and means for elevating one edge of said casing above the said carpet while another edge of said casing remains in contact therewith.

690,100. CONTINUOUS COMPRESSION OF FLUIDS. Adam E. Chodzko, San Francisco, Cal. Filed Sept. 4, 1900. Serial No. 28,925.



A high-speed centrifugal machine, a revoluble shell open upon one side and having inlet and discharge passages, vanes revoluble with the shell and acting to direct the fluid toward the periphery, fixed scoops or collectors, a shaft through which motion is communicated to the shell, and yielding bearings whereby the shell has a freedom of motion about its geometrical center.

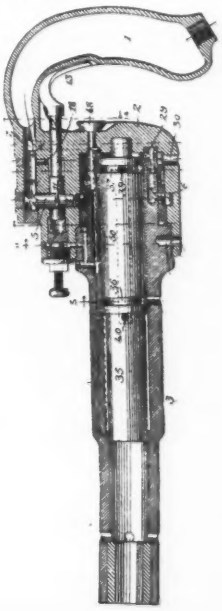
690,087. ROCK-DRILL. Governor D. Warren, Independence, Colo., assignor of one-half to Charles H. McCormick and Solomon I. Lancto, Independence, Colo. Filed Jan. 24, 1901. Serial No. 44,601.

A rock-drill, comprising a cylinder, a piston therein, having a reduced central portion provided with spirally-arranged ratchet-grooves, a valve therefor, and an arm attached to the valve extending into the cylinder and engaging said grooves in the reduced portion of the piston and adapted to oscillate the valve and to rotate the piston.

690,130. STEAM AND AIR COUPLING. Joseph Blattner, Allegheny, Pa. Filed April 11, 1901. Serial No. 55,311.

690,224. HOT-AIR DENTAL APPLIANCE. Henry C. Bagby, Santa Maria, Cal. Filed July 9, 1901. Serial No. 67,658.

690,358. PNEUMATIC HAMMER. William Burlingham, Richmond, Va., assignor of



one-third to William R. Trigg Company, Richmond, Va., a corporation of Virginia. Filed March 26, 1901. Serial No. 52,982.

A pneumatic hammer, means for supplying a constant air-pressure to the piston in a rearward direction, a main valve, and a chamber in said piston in constant communication with said air-pressure, said chamber adapted to communicate with the front side of said main valve when said piston reaches its forward limit of movement to shift said valve to cut off the air-pressure on the rear side of the piston.

690,381. PNEUMATIC VALVE-ACTION. Joseph Wieser, Brooklyn, N. Y., assignor of one-half to Karl Fink, New York, N. Y. Filed April 13, 1901. Serial No. 56,642.

A pneumatic valve-action, the combination, with the main valves controlling the actuating-pneumatics, of auxiliary valves, and means for actuating the main and auxiliary valves, such means comprising tracker-passages, leading on the one hand to the diaphragms of the auxiliary valves and on the other hand to the diaphragms of the main valves.

Westinghouse

Steam and Motor Driven

Air Compressors

Manufactured by

The

Westinghouse Air Brake Co.,

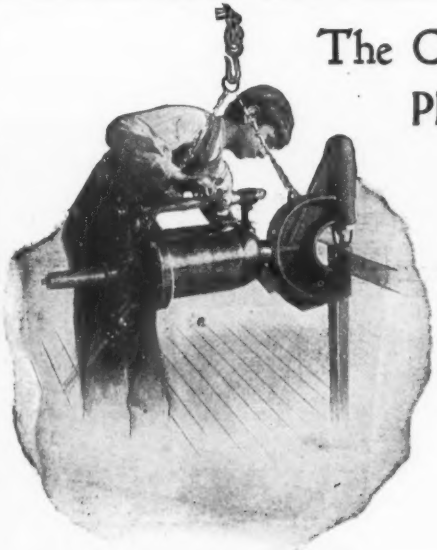
Pittsburgh, Pa.

Builders of the

Air Brake

18 A

COMPRESSED AIR
needs hose and hose needs couplings. And there are two kinds of couplers,
QUICK AS WINK HOSE COUPLINGS
and others. QUICK AS WINK Couplers are easy to connect and disconnect, they are air tight under any pressure, they can't separate when the hose is dragged about, coiled or twisted, no wrench required to make or break connections, they are time savers.
Your fire protection will be better with Quick as Wink Couplers on the Hose.
Write us about it.
The W. J. CLARK CO.,
SALEM, OHIO.
TRADE PAPER ADV. AGENCY, N.Y. NO. 508



Built in four sizes. Cut shows size I.

The Caskey Portable PNEUMATIC PUNCH.

FOR LIGHT AND HEAVY WORK.

Saves exactly half the space in length needed to do the same work with a stationary power punch.

Saves more than half the labor, only one man being required, who can readily do more work than several men on stationery machine.

Saves expense of drilling on many lines of work that cannot be done on power punch.

Avoids much inaccurate work, being so much more easily guided and controlled in the hands of one man than a sheet or beam moved by several men at once.

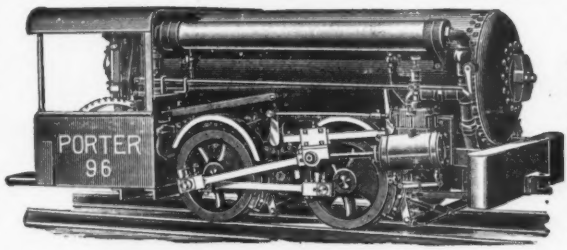
Construction is extremely simple, insuring low cost of repairs.

Prices, references, and all further information, on application to the builders.

F. F. Slocomb & Co.,

WILMINGTON, DELAWARE.

COMPRESSED AIR MINE HAULAGE.



SAFEST, MOST ECONOMICAL, HANDIEST, MOST ADAPTABLE TO VARYING REQUIREMENTS, AND MOST RELIABLE.

We introduced the first air haulage into anthracite mines, and have installed about 90 per cent. of the air locomotives in use in America. We can refer to some 25 plants in operation, each with one to six locomotives, track gauges 18 to 56½ inches, underground and surface haulage. Our designs are automatic, easily controlled and free from complications.

SPECIAL OFFER: On application of Mine Superintendent or official of operation likely to use locomotives, we will mail free our Ninth Edition "Light Locomotives," 233 pages, describing 600 steam and 60 air locomotives. To accommodate others a copy will be mailed on receipt of 50 cents (in stamps if desired).

Address..... **H K. PORTER COMPANY, - - 540 Wood St., Pittsburgh, Pa**

We're making a Specialty of

Filling the foundryman's wants. We're making a specialty of doing this neatly, quickly, and in a way that puts money in his pocket.

We don't undertake any job belonging to the iceman. We don't know anything about cutlery. We couldn't write a respectable looking article about lemon squeezers. Our ideas are very crude regarding fruit jars. Our experience is very limited in setting saws.

We leave all those lines to the journals that "covereth the whole earth."

We don't know it all and we don't try to do it all.

We have "boiled down" and concentrated all our "know how" to the formerly neglected foundry business.

We dish up every month the most appetizing nourishment for all kinds of foundries. Nothing but foundries mind you.

Everyone has paid for his meal ticket too. Not a deadhead sits at our table. No "free soup" goes with us.

Let us sandwich in an advertisement of the stuff you want the foundries to buy.

It will be masticated all right. The orders you will get thereafter will show you that you have not advertised in vain.

THE FOUNDRY,

DETROIT, ∵ ∵ ∵ ∵ MICHIGAN.

CORNELL & UNDERHILL

Wrought and Cast Iron Pipe
Boiler Tubes
Artesian and Oil Well Casing
Iron and Brass Fittings
Valves and Cocks
Gate Valve and Hydrants
Freight, Mine and Dump Cars
Portable Track and Switches
Car Wheels of every description

43, 45 & 47 BEACH ST.

TELEPHONE, FRANKLIN 9490. CABLE ADDRESS, "CUBE," NEW YORK.

Janney, Steinmetz & Co.,

COLD DRAWN, HOT PRESSED AND FORGED

STEEL SHAPES AND SPECIALTIES

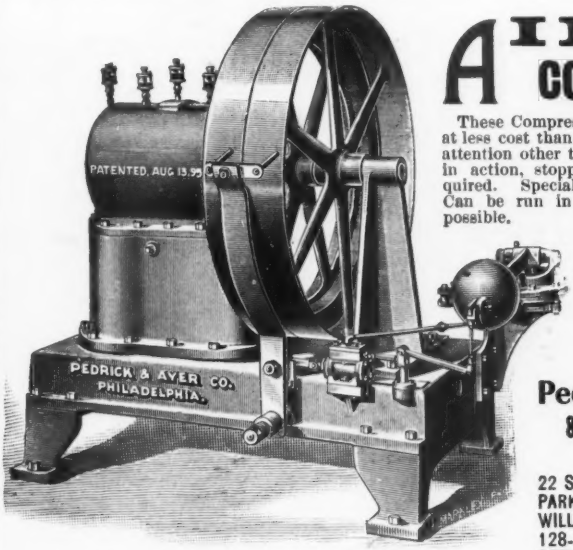
SEAMLESS COLD DRAWN STEEL SHELLS, CYLINDERS AND TANKS

For Air, Water, Steam, Gas, Soda, Ammonia or Fluids under Pressure and Explosives.

SEAMLESS STEEL TUBING, HEAVY SECTION TUBES, HYDRAULIC FORGINGS FOR CREAM SEPARATOR BOWLS, SEAMLESS STEEL TESTED TANKS OF SUNDRY DIAMETERS.

DREXEL BUILDING,

PHILADELPHIA.



AIR COMPRESSORS

These Compressors will compress more air at less cost than any other make, requiring no attention other than oiling; entirely automatic in action, stopping and starting as air is required. Specially adapted for foundry use. Can be run in series; if so, no stoppage possible.

COMPRESSED AIR RIVETERS, HOISTS, CRANES AND OTHER TOOLS.

Send for Catalogue.

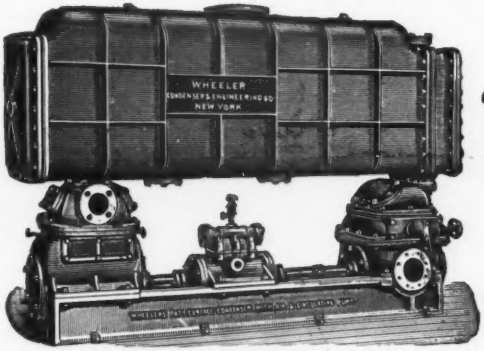
Pedrick & Ayer Co.
85, 87, 89 Liberty St.,
NEW YORK.

22 SO. CANAL ST., CHICAGO, ILL.
PARK BLDG., PITTSBURGH, PA.
WILLIAMSON BLDG., CLEVELAND, O.
128-130 OLIVER ST., BOSTON, MASS.
BETZ BLDG., PHILADELPHIA, PA.

WHEELER CONDENSER & ENGINEERING CO.

NEW YORK.

For MARINE and STATIONARY SERVICE.



SURFACE CONDENSERS Mounted on Combined Air and Circulating Pumps.

PROPRIETORS AND MANUFACTURERS OF

WHEELER STANDARD SURFACE CONDENSER; WHEELER ADMIRALTY SURFACE CONDENSER; WHEELER LIGHTHALL SURFACE CONDENSER; VOLZ PATENT SURFACE CONDENSER AND FEED WATER HEATER; EDMISTON PATENT FEED WATER FILTER.

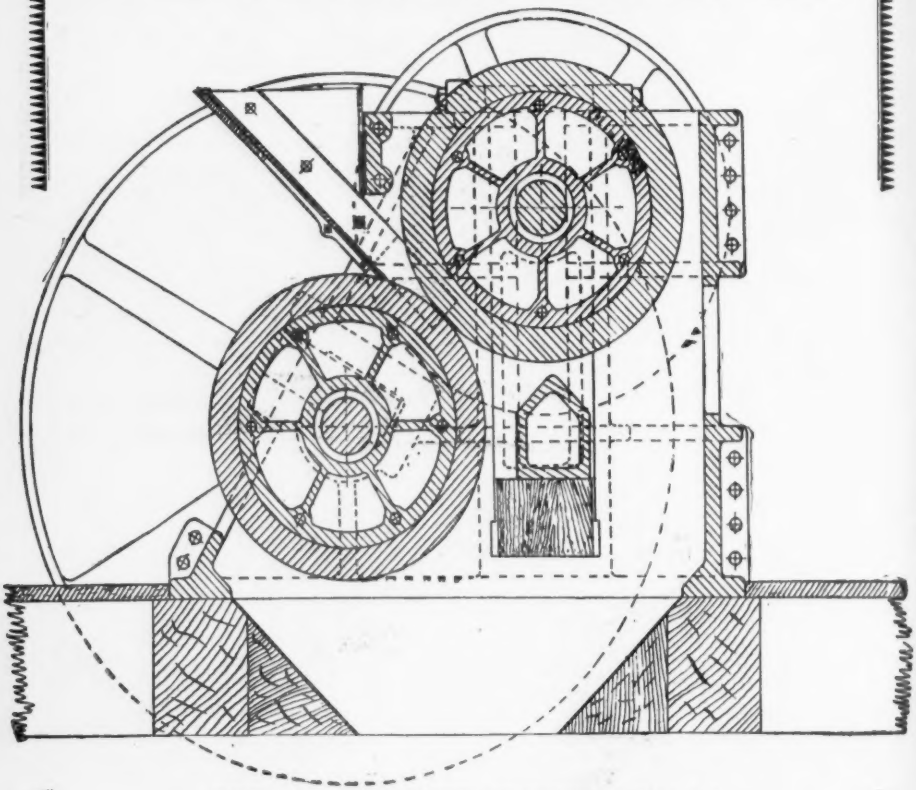
WHEELER'S PATENT FEED WATER HEATER

The Stearns-Roger Manufacturing Company,

CONSTRUCTING ENGINEERS.

Chlorination Mills, Electric Plants

Compressed Air Plants of any capacity.



ROGER'S IMPROVED CRUSHING ROLLS.

Patented in the United States and Foreign Countries.

"These Rolls have been running very satisfactorily and appear to us to be unquestionably the best type of roll yet devised. General Manager,
MOLLIE GIBSON & A. J. MILLS, Aspen, Colorado."

Manufacturers of all classes of Machinery for Mining and Metallurgical requirements.

MAIN OFFICE, 1718-24 CALIFORNIA STREET, DENVER, COLO., U. S. A.

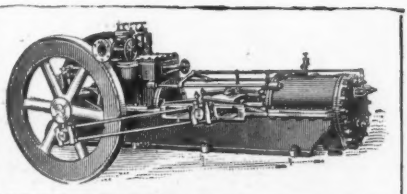
THE ENGINEERING MAGAZINE

AN INDUSTRIAL REVIEW

The Engineering Magazine has been aptly described as "*The Century* of the industrial world and the *Review of Reviews* to engineering literature—the two in one." Its leading articles treat the subjects uppermost in importance in industrial affairs. Its contributors include the foremost men of our times. It gives each month an exhaustive Review and Index to the world-wide range of technical literature—American, English, French, and German. It is read in every nook and corner of the civilized world. It is founded upon the idea of meeting the requirements of the busy and brainy men who manage, think, and plan for the engineering, architectural, electrical, railroad, mining, and mechanical industries. It has a larger bona-fide circulation among such men than has ever been attained by an engineering journal in all the history of industrial literature. It is priceless to the active man who needs to keep in touch with current developments. Its every page carries a living interest for intelligent readers who are in any way concerned with modern industrial enterprises. Its subscribers are its warmest advocates and the Magazine itself is its best solicitor. *Sample copy free.*

30 Cents a Number; $3.00 a Year.

THE ENGINEERING MAGAZINE,
120-122 Liberty St., New-York, U. S. A.



McKiernan Drill Co.,

120 LIBERTY STREET,
NEW YORK,

MANUFACTURERS OF

Rock Drills, Etc.
Air Compressors

Various Types. Special Designs. Suitable for all Dynamic Purposes.

SOLE AGENTS FOR THE

Kennedy Patent Air Lift.

NOW READY

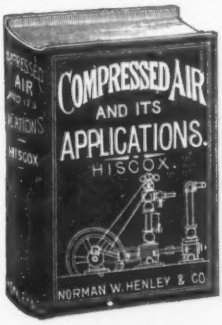
COMPRESSED AIR

ITS USES AND APPLICATIONS

LARGE 8vo. ABOUT 700 PAGES. 600 HANDSOME ILLUSTRATIONS.

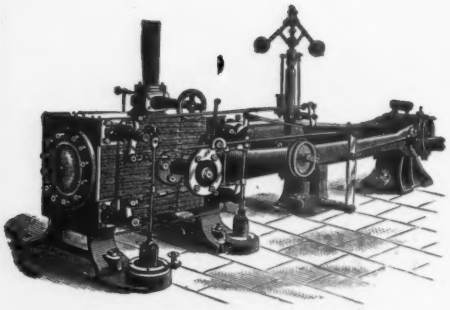
By GARDNER D. HISCOX, M.E.

PRICE, $5.00.



A complete treatise on Compressed Air, comprising its physical and operative properties from a vacuum to its liquid form. Its thermodynamics, compression, transmission, expansion, and its uses for power purposes in mining and engineering work; pneumatic motors, shop tools, air blasts for cleaning and painting. The Sand Blast, air lifts, pumping of water acids and oils; aeration and purification of water supply, are all treated, as well as railway propulsion, pneumatic tube transmission, refrigeration. The Air Brake, and numerous appliances in which compressed air is a most convenient and economical vehicle for work—with air tables of compression, expansion and physical properties. Copies of this book will be sent prepaid to any address on receipt of price. Address

COMPRESSED AIR, 26 Cortlandt St., New York



Established
1833.

The

C. & G. COOPER CO.

MT. VERNON, OHIO.

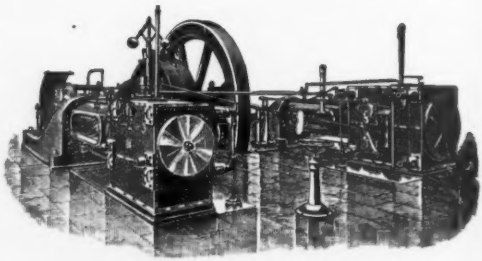
CORLISS ENGINES.

COMPOUND.

TRIPLE EXPANSION.

SINGLE CYLINDER.

Of all sizes up to 3,000 Horse-power.



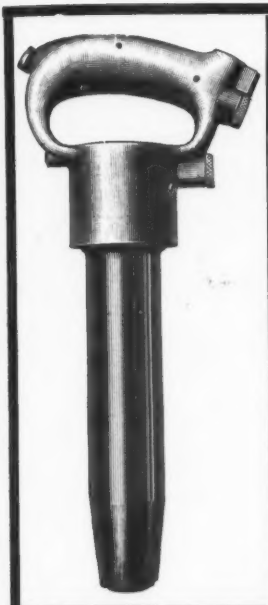
—FOR—

FACTORIES, RAILWAYS, ELECTRIC LIGHTING
ROLLING MILLS, AND ALL KINDS
OF MANUFACTURING.

CORRESPONDENCE SOLICITED.

HOME OFFICE: MT. VERNON, OHIO.

NEW YORK: Room 1022 Havemeyer Building, F. W. IREDELL, Mgr.



Close Questions.

Has any firm pneumatic tools that work faster than yours, or that stand hard usage better?

Yes—unless you use ours.

Then how are you going to compete? Will you lose part of the profit, or lose the order?

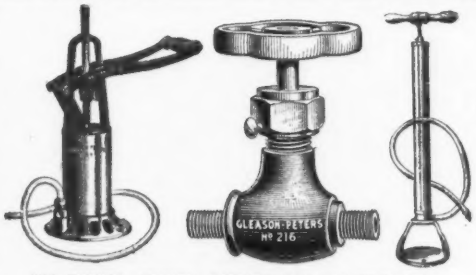
Answer by mail.

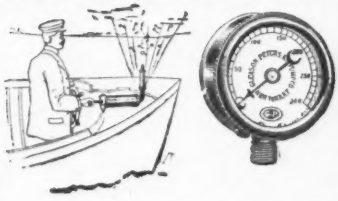
Send for catalogue of our Pneumatic Chipping and Riveting Hammers, Rotary Drills, Rammers, etc.

Philadelphia Pneumatic Tool Co.

1038 Ridge Avenue, Philadelphia

New York Chicago Pittsburgh





FOR ALL PURPOSES WHERE COMPRESSED AIR IS REQUIRED

AIR PUMPS, TANKS, GAUGES, AND AIR FITTINGS

GLEASON-PETERS AIR PUMP CO., - 20 West Houston Street, N. Y. C., U. S. A.

Compressed Air.

Practical information upon Air-Compression and the Transmission and Application of Compressed Air.

By FRANK RICHARDS. 12mo, cloth, $1.50

John Wiley & Sons, New York.

DO YOU KNOW

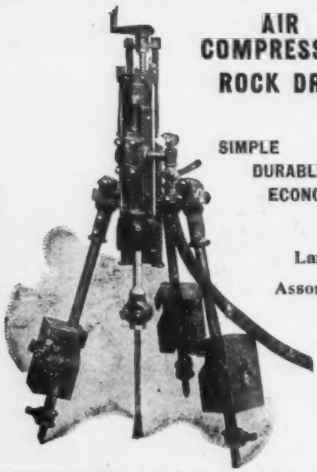
That the Wisconsin Engineer is a first class college quarterly of engineering.

WE KNOW

That it would be a dollar well spent if you should send it to

THE WISCONSIN ENGINEER,
Madison, Wis.

MINING MACHINERY



AIR
COMPRESSORS
ROCK DRILLS

SIMPLE
DURABLE
ECONOMICAL

Large
Assortment
of
Styles
and
Sizes

SULLIVAN MACHINERY CO.,
SUCCESSORS TO
M. C. BULLOCK MFG. CO.,
135 ADAMS ST., CHICAGO.

Double Your SALARY

Our free booklet, "Are Your Hands Tied?" tells you how to do it. Thousands have largely increased their salaries by following our plan.

WE TEACH BY MAIL Mechanical or Electrical Engineering; Drawing; Architecture; Bookkeeping; Ornamental Design; German; Spanish; French, etc. Circular free. State subject that interests you.

International Correspondence Schools,
Box 1132, Scranton, Pa.

Used by the Officers of all Railroads

THE OFFICIAL RAILWAY EQUIPMENT REGISTER

(ISSUED QUARTERLY)
Subscription Price, $1.00 per annum.

THE POCKET LIST OF RAILROAD OFFICIALS
Advertising rates on application.

(ISSUED MONTHLY)
Descriptive of freight and passenger cars of the Railways and Private Companies in the United States, Canada and Mexico.
Subscription Price, $5.00 per annum. Single copies, $1.00.

THE RAILWAY EQUIPMENT & PUBLICATION CO.
24 Park Place, New York.

ARIZONA

THE LAND OF

Gold and Silver and Copper and Climate

Send 25 cents for Special 3 mos. subscription to

THE ARIZONA MINING PRESS

(semi-monthly, $2.00 per year.)

Frederick Webb, Editor, Phœnix, Arizona.

FOUNDRY MOULDING MACHINES

OPERATED BY

COMPRESSED AIR.

Vibrator principle, avoiding stripping plates and expensive patterns, for both power and hand ramming.

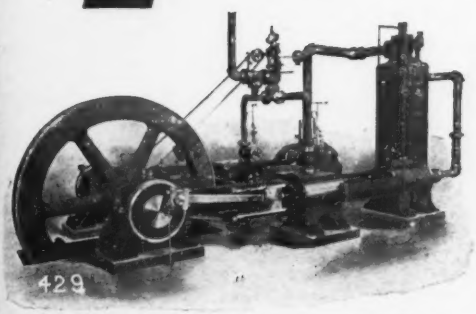
Write us to learn how nearly we have reduced pattern cost to nothing.

THE TABOR M'F'G CO.,

18th & Hamilton Sts., Philadelphia, Pa.

THE
INGERSOLL-SERGEANT
DRILL COMPANY,
26 Cortlandt St., New York.

AIR
COMPRESSORS



COMPOUND.

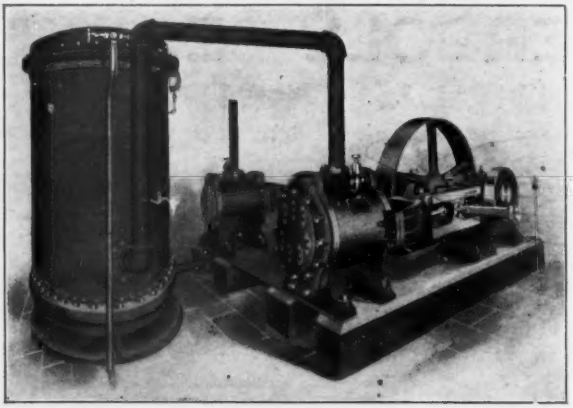
COAL
CUTTERS

ROCK
DRILLS

New York=Franklin AIR COMPRESSORS

IN ALL SIZES AND TYPES.

PNEUMATIC TOOLS OF EVERY DESCRIPTION



COMPLETE COMPRESSED AIR PLANTS INSTALLED AND GUARANTEED

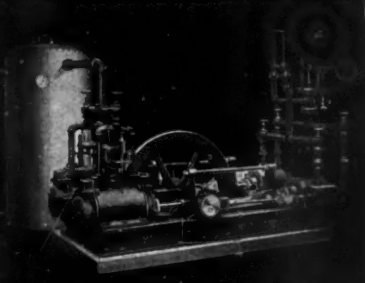
CHICAGO PNEUMATIC TOOL CO.,

MONADNOCK BLOCK, CHICAGO. - - 95 LIBERTY STREET, NEW YORK.

Works: Detroit, Mich.; Franklin, Pa.; Cleveland, O.; Olney, Phila.

Air Compressors

For Operating
PNEUMATIC TOOLS,
HOISTS, ROCK DRILLS
and every other application of Compressed Air.



CLAYTON AIR LIFT SYSTEM
BREWERS AIR PUMPS

Clayton Steam Duplex Type.

CLAYTON AIR COMPRESSOR WORKS,

Catalogue.

26 CORTLANDT ST., NEW YORK.